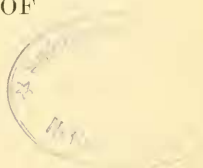


ASCIDIANS OF THE LITTORAL ZONE OF  
SOUTHERN CALIFORNIA

BY

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(Contribution from the Scripps Institution for Biological Research)



The aim of this paper is mainly to contribute to the knowledge of the ascidian fauna of the California coast south of Point Conception. In it are included descriptions of all the new species of which specimens are contained in available collections; also a list, with supplementary notes, of all the species of the region previously described from the same area. This limitation in the scope of the study has led us to exclude from it a considerable number of species which in all probability ought to be included, but are not, because they are known to us only from the localities north of the Point. More exhaustive collecting, particularly on the Santa Barbara Islands and the opposite mainland, will undoubtedly bring to light many species which we now know only from northern localities, where much more collecting has been done than anywhere south of the Point excepting the San Pedro and San Diego regions.

The considerable number of species here recorded as occurring at La Jolla and San Diego only may be taken as indicative of what is to be expected when other portions of the coast have been as well searched for ascidians as this. Nor should it be supposed that even the La Jolla-San Diego region has been exhausted.

The two lists here given of species, with the families to which they belong, include all the ascidians of the southern California littoral zone known to science, and also those not yet known from the littoral, but occurring off shore in depths of water so shallow that they may be expected to be found on shore.

## LIST OF SPECIES

- Family Molgulidae  
 1. *Molgula verrucifera*, n. sp.
- Family Halocynthiaidae  
 2. *Halocynthia johnsoni* Ritt.
- Family Styelidae  
 3. *Styela montercyensis* (Dall)  
 4. *Styela gibbsii* (Stimp.)  
 5. *Styela barnharti*, n. sp.
- Family Ascidiidae  
 6. *Ascidia californica*, n. sp.
- Family Rhodosomidae  
 7. *Cheylosoma productum* Stimp.
- Family Cionidae  
 8. *Ciona intestinalis* L.
- Family Polyzoidae  
 9. *Metandrocarpa dura* (Ritt.)  
 10. *Metandrocarpa michaelsoni*, n. sp.  
 11. *Polyzoa translucida*, n. sp.
- Family Botryllidae  
 12. *Botryllus tuberatus*, n. sp.  
 13. *Botrylloides diegenis*, n. sp.
- Family Perophoridae  
 14. *Perophora annectens* Ritt.
- Family Polyeitoridae  
 15. *Distaplia occidentalis*, n. sp.  
 16. *Eudistoma psammion*, n. sp.  
 17. *Eudistoma diaphanes*, n. sp.
- Family Didemnidae  
 18. *Didemnum carnulentum*, n. sp.  
 19. *Didemnum carnulentum lacteolum*, n. var.  
 20. *Trididemnum dellavallei*, n. sp.  
 21. *Diplosoma pizoni*, n. sp.  
 22. *Diplosomoides caulleryi*, n. sp.
- Family Synoicidae  
 23. *Glossophorum planum*, n. sp.  
 24. *Macroclinum par-fustis*, n. sp.  
 25. *Macroclinum pellucidum*, n. sp.  
 26. *Amaroucium californicum*, n. sp.  
 27. *Amaroucium solidum*, n. sp.  
 28. *Amaroucium aequali-siphonis*, n. sp.  
 29. *Euherdmania claviformis* Ritt.

To be added to these without much doubt, because known from depths of 50 fathoms and less are:

1. *Halocynthia oka* Ritt.  
 (Known in depth of 10-80 fath. Ritter, 1907.)
2. *Microcosmus transversus* Ritt.  
 (Known in 33 fath. Ritter, 1907.)
3. *Boltenia echinata* Ritt.  
 (Known in 21 fath. Ritter, 1907.)

4. *Styela hemicacpitosa* Ritt.  
(Known in 29 fath. Ritter, 1913.)
5. *Ascidia (Phallusia) vermiformis* Ritt.  
(Known in 30 fath. Ritter, 1913.)
6. *Psammoplidium spauldingi* Ritt.  
(Known in 33 fath. Ritter, 1913.)
7. *Trididemnum (Didemnum) opacum* Ritt.  
(Known in 33 fath. Ritter, 1913.)

Search for these seven species in the littoral zone will be among the interesting motives of future ascidian collecting.

#### SYNOPTIC DESCRIPTIONS OF GENERA

The following synoptic description and arrangement of the genera, representatives of which are treated in the paper, has been drawn up primarily for the use of students, other than specialists on ascidians, who may want to use the local species in more general zoological or biological studies. This being the main purpose, questions of the best system of classification and nomenclature, with which specialists in the group are much interested at present, are considered no further than to make sure that all descriptions, definitions, arrangements, and names have the sanction of at least some of the most experienced ascidiologists.

##### Suborder I. ASCIDIAE SIMPLICES

Individual animals of considerable size, rarely less than 1 cm. in diameter; very irregular in form but predominantly massive; sometimes semitransparent, sometimes leathery in appearance, sometimes coated with sand; sedentary; often firmly attached to rocks and other objects in adult life; never, as here understood, propagating by budding.

##### Genus 1. *Molgula* (*Caesira*, some authors)

*Body* usually unattached because the animal lives on sandy or muddy bottoms, but sometimes attached to rocks, occasionally pedunculated. Branchial orifice 6-lobed, atrial 4-lobed.

*Outer coat* (test) somewhat cartilaginous, leathery or membranous, frequently covered with sand, which may be attached to hairlike processes or embedded in the surface layer.

*Branchial tentacles* always compound.

*Branchial sac* with well-developed folds, usually from five to seven on each side; the branchial slits (stigmata) almost always curved, or even developed into spirals and arranged in pockets or ampullae in the branchial folds.

*Intestine* always on the left side.

*Sexual organs* usually on both sides but not infrequently on one side only; when so, almost always on the left. Ovary and testis more or less intimately associated.

*Excretory organ* on the right side only, with the exception of one genus, *Rhizomolgula*, in which it is on the left side.

Genus 2. *Halocynthia* (*Pyura*, some authors)

*Body* mostly approaching globular, always firmly attached, sometimes short-pedunculate; surface usually free from foreign substances but often bearing processes of various kinds; both orifices 4-lobed.

*Outer coat* (test) usually leathery, rather cartilaginous and semitransparent. *Branchial tentacles* always compound.

*Branchial sac* with folds, usually well developed; prevalent number from four to seven, but a few species with a smaller number and a few with as many as fifteen; dorsal lamina always with processes or languets.

*Intestine* on the left side, forming a wide loop.

*Sexual organs* on both sides.

Genus 3. *Styela* (*Tethyum*, some authors)

*Body* attached, not infrequently pedunculate, sometimes coated with sand; both orifices 4-lobed, often inconspicuously so.

*Outer coat* leathery, usually thin, surface typically unarmed.

*Tentacles* both branchial and atrial present, both kinds simple, branchial larger.

*Branchial sac* with four folds on each side, some of which may be much reduced in size.

*Intestine* on left side, stomach frequently long with narrow folds in the wall.

*Sexual organs* on both sides, ovary typically in several sausage-shaped masses with the testes arranged about them in smaller lobes.

Genus 4. *Ascidia* (*Phallusia*, some authors)

*Body* attached, almost always sessile, surface usually smooth and free from foreign substances; branchial orifice 8-lobed, atrial 6-lobed.

*Outer coat* usually transparent or nearly so, soft or cartilaginous.

*Branchial tentacles* simple, usually numerous and slender.

*Branchial sac* never with prominent folds, but often with many small plications; papillae on the inner surface at the intersections of the longitudinal and transverse vessels; dorsal lamina a membrane extending behind the esophageal opening.

*Intestine* on the left side.

*Sexual glands* situated within the intestinal loop.

*Renal vesicles* present, numerous, confined to the wall of the intestine.

Genus 5. *Chelyosoma*

*Body* flattened from above, the upper surface covered with tortoise-shell-like plates; both orifices 6-lobed.

*Outer coat* cartilage-like, translucent, the anterior part differentiated into horny plates.

*Branchial sac*, general type that of *Ascidia* and *Ciona*, but stigmata strongly curved or coiled; dorsal languets as in *Ciona*.

*Intestine* located ventrally, sometimes to the right, sometimes to the left; stomach wall, in part, chambered.

*Sexual organs* forming a network on the intestinal loop.

Genus 6. *Ciona*.

*Body* cylindrical, attached; branchial orifice 8-lobed, atrial 6-lobed, lobes not prominent.

*Outer coat* thin, transparent, soft.

*Branchial tentacles* simple, slender.

*Branchial sac* much as in *Ascidia*, but with a series of languets in place of dorsal lamina.

*Intestine* wholly or largely behind the brancial sac.

*Sexual organs* in the intestinal loop.

#### Suborder II. ASCIDIAE COMPOSITAE

Individuals, called zooids, produced asexually by budding; typically many; small, usually less than 1 cm. long; in most genera connected together by permanent stolons and embedded in a common mass of cellulose mantle or test; but in some genera zooids larger and not fully embedded in the common mass; the whole group of zooids, produced from a single parent, called a colony.

##### Genus 7. *Metandrocarpa*

*Colony* encrusting on rocks, seaweeds, and other objects; zooids never arranged in systems; cellulose mantle tough; color brick-red.

*Form of zooid* globular, body not divided into sections.

*Branchial sac* without folds but with internal longitudinal vessels; branchial and atrial tentacles present, all simple.

*Intestine* short, situated on the left-ventral side of the branchial sac; stomach with a series of folds and a large caecum.

*Sexual glands* two series of masses called polycarps, one on each side of the endostyle, each polycarp with its own short duct opening into the perbranchial chamber; the anterior polycarps of each series female, the posterior male.

*Budding* thoraic.

##### Genus 8. *Polyzoa*

Like *Metandrocarpa* except:

*Colony* with zooids united only by strands; no common investing cellulose mass; colorless, transparent.

*Sexual glands* all hermaphroditic polycarps.

##### Genus 9. *Botryllus*

*Colony* thin and encrusting; zooids wholly embedded in common cellulose mass, arranged in regular or somewhat elongated "systems" around a common atrial opening; cellulose mass containing many vessels terminating in ampullae; color various, often very conspicuous.

*Form of zooids* generally elliptical, body not divided into sections.

*Branchial sac* without folds but with a few internal longitudinal vessels.

*Intestine* on left side at posterior end; stomach with folds and a caecum.

*Sexual glands* a single pair of hermaphroditic masses, one on each side of a branchial sac.

*Budding* thoraic.

##### Genus 10. *Botrylloides*

Like *Botryllus* except:

*Colony* with zooids arranged in long-elliptical or tortuous systems.

##### Genus 11. *Perophora*

*Colony* composed of zooids conected by stolons, partly or wholly embedded in cellulose mass; zooids never in systems; transparent to yellowish white.

*Form of zooids* spheroid, body not divided into sections; branchial orifice 6-lobed, atrial 5-lobed.

*Branchial sac* without folds, with internal longitudinal vessels or papillae; a series of languets along mid-dorsal line.

*Intestine* on left side; stomach wall not folded, intestine divided into several distinct sections.

*Sexual organs* on left side in the intestinal loop, ovary a single mass, testes in numerous lobes.

*Budding* stolonie.

Genus 12. **Distaplia** (Holozoa, some authors)

*Colony* usually consisting of short club-shaped or capitate masses closely united at base; zooids typically in systems with distinct common atrial orifices; cellulose mass soft, usually highly colored.

*Form of zooids*: body elongated, separated into thorax containing branchial sac, and abdomen containing intestine and sexual organs; branchial orifice 6-lobed, atrial with a long dorsal tongue, or languet.

*Branchial sac* with neither folds nor internal vessels, four series of stigmata.

*Intestine* a simple, elongated loop; stomach ovate, wall not folded but with a network of fine ridges on inner surface.

*Sexual organs*: gonads situated on the right-posterior part of the intestinal loop, ovary very simple, ripe ova large; testis composed of a few masses; larvae develop in an incubating pouch.

*Budding* stolonie.

Genus 13. **Eudistoma**

*Colony* massive and variously lobed; dull white or dark from covering of sand; zooids not usually grouped in systems.

*Form of zooids*: body elongated, divided into thorax and abdomen; a long ectodermal process usually given off from posterior end of abdomen; orifices each 6-lobed.

*Branchial sac* simple with few (three to five) series of stigmata.

*Intestine* a long, nearly straight, simple loop; stomach smooth-walled, frequently far back in the abdomen.

*Sexual organs*: gonads alongside the intestinal loop, far back; ovary simple; testis of numerous lobes; no incubating pouch.

Genus 14. **Didemnum**

*Colony* always closely encrusting, usually very thin, rarely somewhat massive; cellulose material containing stellate calcareous spicules; zooids not in systems; color white or variously tinted.

*Form of zooid*: divided into thorax and abdomen; branchial orifice 6-lobed, atrial orifice plane, situated on dorsal side of thorax.

*Branchial sac* with four rows of stigmata.

*Intestine* a simple loop, its posterior part usually containing the stomach; stomach smooth-walled.

*Sexual organs* situated on the left-posterior side of the intestinal loop; ovary very simple, ripe ova very large; vas deferens wound in a close spiral around the testis.

Genus 15. **Trididemnum**

Scarcely differing from *Didemnum* except in the number of stigmatic series, these being here three; colony perhaps typically somewhat more fleshy.

Genus 16. **Diplosoma**

*Colony* mostly thin and encrusting, soft and lax because of numerous great spaces in the transparent cellulose mass; systems where present very irregular.

*Form of zooids*: divided into thorax and abdomen; not sharply separated from each other; branchial orifice 6-lobed, atrial a large, simple opening.

*Branchial sac* with four rows of stigmata.

*Intestine* a simple loop; stomach smooth-walled.

*Sexual organs*: gonads on right-posterior side of intestinal loop; ovary simple, eggs very large, few in number; testis not many-lobed, vas deferens not coiled.

*Budding* intestinal.

Genus 17. **Diplosomoides**

Similar to *Diplosoma* but *calcarious spicules* in the cellulose mass; a *lanquet* over the atrial orifice.

Genus 18. **Glossophorum**

*Colony* massive, sub globular or lobed, sometimes pedunculate; zooids mostly in distinct systems.

*Form of zooid* much elongated; body divided into three sections: thorax, abdomen, and postabdomen; branchial orifice 6-lobed, atrial with a *lanquet*.

*Branchial sac* well-developed, as many as twenty rows of stigmata; papillae on the inner surface of the branchial membrane along the interserial vessels.

*Intestine* a close, twisted loop situated close behind the thorax; stomach smooth-walled.

*Gonads*, ovary and testis commingled, making a rather compact mass, situated in the stalked postabdomen.

*Budding* stolonial.

Genus 19. **Macroclinum**

*Colony* massive or divided into club-shaped pieces; sometimes coated with sand.

*Form of zooid* elongated, divided into thorax, abdomen, and postabdomen, the last not constricted from the abdomen and variable in size and make-up; branchial orifice 6-lobed, atrial with a well-developed *lanquet*.

*Branchial sac*: many rows of stigmata, twenty in some species.

*Intestine*: loop not twisted, stomach wall not folded but inner surface uneven in some species.

*Gonads* close behind the intestinal loop; ovary simple, surrounded by the numerous masses of the testis.

*Budding* stolonial.

Genus 20. **Amaroucium**

*Colony* variable, thin and encrusting, massive or divided into pedunculated sections.

*Form of zooid* elongated, divided into thorax, abdomen, and postabdomen, the latter often long and cylindrical; branchial orifice 6-lobed, atrial with a *lanquet*.

*Branchial sac*: rows of stigmata, mostly less than twenty.

*Intestine*: loop simple, stomach wall folded.

*Gonads* in the postabdomen, usually somewhat removed from the intestinal loop; ovary simple, testis many-lobed, scattered along the postabdomen.

Genus 21. **Euherdmania**

*Colony* consisting of large, elongated zooids, wholly separated from one another except for the basal stolonial attachments, making the condition commonly known as social; color opaque white, or transparent.

*Form of zooids*: length as great as 3 cm.; divided into thorax, abdomen, and postabdomen, the last very short; both orifices 6-lobed.

*Branchial sac* with twelve rows of stigmata.

*Intestine* a very long, simple loop, the esophagus making one of its limbs; stomach with folded wall situated near the loop.

*Sexual organs*: gonads in the short postabdomen; ovary simple; testis in many separate masses; embryos developed in the long, straight oviduct.

*Budding* not known, probably stolonial.

## DESCRIPTION OF SPECIES

NOTE.—The formula for the number and arrangement of vessels on the inner surface of the branchial membrane of simple ascidians, adopted by Ritter in his later papers on ascidian taxonomy, is used in the descriptions. Thus:

$$e'd's \begin{cases} 1-7-2-6-0, \text{ etc.} & R. \\ 2-8-1-7-2, \text{ etc.} & L. \end{cases}$$

means that counting from the endostyle (e'd's) the vessels of the right side (R) number 7-6, etc., on the folds and 1-2-0, etc., between the folds. The other row of numbers is self-explanatory.

**Molgula verrucifera**, n. sp.

Pl. 38, fig. 5; pl. 40, figs. 15-20

*Superficial characteristics.*—Regular in outline except for adhering foreign bodies, nearly spherical but usually somewhat depressed and covered with heavy coating of sand. Siphons not far apart and rather conspicuous though entirely covered with sand (pl. 38, fig. 5). Size: 8 by 6 by 5 mm.; 8 by 7 by 6 mm.; 8 by 7 by 5 mm.; 8 by 6.5 by 6.5 mm.; 8 by 6 by 6 mm.; 8 by 6.5 by 9 mm.; 10 by 8 by 7.5 mm. Test thin but firm, sandy covering adhering to its numerous fine processes. Mantle thin; the longitudinal muscle bands radiate from the siphons and spread out on the sides of the body so as to be separated by considerable spaces, extending to about the middle of each side. Finer circular muscle bands are confined to the siphonal regions. Musculature of the two siphons about the same in strength.

*Branchial system.*—When removed from the test, the two siphons are of about equal length although atrial is usually more slender. Branchial orifice 6-lobed with tentacle-like processes inserted around its edge. Of these processes six long ones are arranged symmetrically and alternating with them are two smaller processes (pl. 40, fig. 18). Atrial orifice 4-lobed, also with tentacle-like processes inserted on its edge (pl. 40, fig. 17). Branchial tentacles 16-20, usually of two sizes alternating with each other and closely crowded around branchial orifice. Each tentacle bipinnate, the branches ending bluntly and often swollen at tips (pl. 40, fig. 19). Hypophysis opening an elongated slit, the ends of which may curve one way or the other to give rise to the variations which appear in different individuals, situated on right side of anterior end of the elongated ganglion (pl. 40, fig. 20). Branchial sac with seven well-developed folds on each side (*b.f.* pl. 40, fig. 15), those next to the dorsal lamina very short. Formula of internal longitudinal vessels:

$$e'd's \begin{cases} 1-0-6-0-6-0-6-0-6-0-3-0- & R. \\ 3-0-5-0-6-0-6-0-6-0-5-0-3-0- & L. \end{cases}$$

The vessels are confined to surface and upper halves of the curved folds, usually the same number on each side, but those on convex sides always stronger. Five primary transverse vessels occur, intercepting two infundibula on each fold. Secondary transverse vessels present.



one between each of the two infundibula thus intercepted. Finally tertiary vessels are often found on the faces of the infundibula, where they divide the stigmata of the faces and separate the two short spirals which, in such cases, often occur at the spaces of the infundibula. Usually the stigmata at the apex of an infundibulum form a single short spiral (pl. 40, fig. 16). At the posterior end of the sac, the stigmata become irregular, assuming s-shaped and spiral forms. Dorsal lamina a plain membrane with thickened edge. Endostyle (*end.*, pl. 40, fig. 15) long and slender.

*Digestive system.*—Situated on left side of the body, forming a long closed loop which in turn forms a regular curve on posterior dorsal portion of that side (pl. 40, fig. 15). Esophagus (*e.*), not quite as long as stomach, emerges from dorsal posterior portion of branchial sac. Stomach (*s.*) thin-walled, smooth, over twice as long as wide, and of not much greater diameter than intestine. On inner surface of esophagus and stomach, and extending beyond them is a voluminous rosette-shaped reddish-brown liver (*l.*, pl. 40, fig. 15). This made up of two distinct portions, each consisting of numerous radiating elongated caeca. Anus plain-edged, situated in peribranchial cavity near the emergence of esophagus and near atrial siphon. Kidney bean-shaped, and located on right side and ventral portion of the body just posterior to ovary, to which it is almost equal in size.

*Reproductive system.*—Consists of two hermaphroditic gonads, one on each side of the body. Ovaries large, irregularly oval, somewhat flattened bodies, that on left side situated just anterior to intestinal loop (pl. 40, fig. 15). Short oviduct arises from anterior edge of ovary and opens into peribranchial cavity where the larvae develop. Specimens taken in July and in October had numerous tadpoles. Testicular lobes (*t.*, pl. 40, fig. 15) comparatively few, situated on posterior border of ovary.

*Habitat and distribution.*—On the exposed surfaces of rocks usually, but sometimes on the under surfaces, in the littoral zone, La Jolla, California. *M. verrucifera* undoubtedly occurs at other places than La Jolla but has not yet been collected elsewhere.

This species belongs to the small group of molgulids in which both branchial and atrial orifices are armed with well-developed processes. On this basis it would fall into the genus *Cetenicella* as defined by Lacaze-Duthiers. We agree, however, with those recent ascidiologists who consider the group recognized by this author as too small and heterogeneous to be profitably accepted as a genus. Nor does our species come near to accommodating itself to *Cetenicella* as redefined by Hartmeyer. There is no course open to us, therefore, but to place it in the genus *Molgula*, in which group it occupies a fairly distinct place by virtue of the possession of the siphonal processes.

The specific name has reference to the wart-like appearance of the siphons even in preserved specimens.

**Halocynthia johnsoni** Ritt.

*Halocynthia johnsoni*, Ritter, 1909.

A striking thing about this species is its great abundance in San Diego Bay, and the large size reached there by the individuals, as compared with what one finds on the open shores. Its favorite habitat appears to be the piles of wharfs where, at times, it makes almost a solid coating. Although it must be counted as a native of the whole littoral zone, we have found only occasional small specimens at outside points.

Mention may be made of the fact that before San Pedro Bay was completely dredged to make it a harbor, *H. johnsoni* occurred there in the shoaler waters in enormous numbers on the bottom, associated with several species of lamellibranch molluses.

**Styela montereyensis** (Dall)

Pl. 38, fig. 1; pl. 41, fig. 28-34

*Cynthia(?) montereyensis*, Dall, 1871, p. 157.

*Clavelinopsis rubra*, Fewkes, 1889.

*Boltenia(?) rubra*, Herdman, 1891, p. 599.

*Styela montereyensis*, Ritter, 1893, p. 39.

*Styela montereyensis*, Bancroft, 1899, pp. 73 and 92.

*Styela* (sens. restr.) *montereyensis*, Huntsman, 1911, p. 131.

Although *Styela montereyensis* was, so far as we know, the first ascidian ever described from the California coast, and though it has been studied more, probably, than any other, because of the meagerness of the original description we describe it as fully as though it were a new species.

*Superficial characteristics* (pl. 38, fig. 1).—Long, club-shaped, pedunculated; prevailing color dark red. Peduncle at least as long as body, often twice as long. Test firm, thick, opaque, with about twelve corrugations. Transverse wrinkles often occur, particularly at anterior end and along peduncle. Both orifices 4-lobed; siphons always distinct, the branchial being directed ventrally with a pronounced uniform curve, the atrial directed anteriorly. Body merges gradually into peduncle. Mantle fairly muscular but semitransparent, containing two layers of muscle, an inner one of longitudinal bands overlaid by a more delicate layer of transverse fibers crossing it at right angles; both layers become feeble posteriorly and wholly disappear in the peduncle.

Table 1 gives measurements for *Styela montereyensis* from different localities.

TABLE 1

*Styela montereyensis*

Locality	Length of body	Length of peduncle	Longitudinal vessels of sac	Number of branchial tentacles
San Diego Bay	10 em.	19 em.	end { 7-14-10-16-13-16-9-22-7 R. 6-14-15-16-12-16-11-22-7 L.	133
Pacific Grove	8 em.	8 em.	end { 6-13-9-11-7-14-8-17-6 R. 6-12-9-11-8-15-9-18-6 L.	100
Trinidad	3.5 em.	8 em.	end 6-9-8-8-4-8-4-14-6 R.	80
Northern Mendocino County	3.5 em.	5 em.	end 3-6-4-8-4-7-5-10-3 R.	60
Northern Mendocino County	3 em.	3.5 em.	end 2-4-4-5-5-4-4-10-3 R.	55
Patrick's Point	2.5 em.	8 em.	end 3-7-5-8-5-8-5-12-5 R.	65
Coronado	2.5 em.	2.5 em.	end 3-4-5-6-3-4-3-8-2 L.	65
Half Moon Bay	1.8 em.	2 em.	end 2-4-4-5-3-4-3-6-2 R.	50
Point Conception	1.6 em.	1.8 em.	end 2-7-3-10-3-7-3-12-3 R.	56
Pebble Beach	1 em.	1 em.	end 2-5-3-6-3-5-2-8-3 R.	40

*Branchial system.*—Branchial tentacles numerous, long, slender, inflated, varying in size and number, maximum being about 130 (pl. 41, fig. 30). Atrial tentacles numerous, fliform, scattered over inner surface of a velum near base of atrial siphon; outer surface of velum applied to wall of atrial siphon (pl. 41, fig. 32). Dorsal tubercle prominent, hypophysis mouth of horseshoe type, varying greatly in different individuals. Branchial sac with four folds on each side, those next the dorsal lamina having the greatest number of longitudinal vessels. Longitudinal vessels on folds and in spaces vary greatly in number with size of individual. Transverse vessels cross longitudinal vessels and produce the meshes which are about square. Number of stigmata in a mesh from three to ten. Dorsal lamina a plain membrane. Endostyle tortuous at anterior end. Spinules occur on inner surface of siphons, their free margins rounded and their surfaces longitudinally striated (pl. 41, figs. 33 and 34). Each spinule a single cell with a single nucleus situated somewhat nearer the base than the apex of the cell. The longer, more or less pointed striated part of the cell is a thin, indurated layer making something like a shield on the cell's back. The existence, in an animal as high in the animal kingdom as the ascidians, of structures which consist of a single cell and present differences in different species, is a fact deserving special mention. Huntsman (1911) was the first to describe the spinules in detail, and we are glad to be able to confirm his observation that the structures are regularly different, at least as between *S. montereyensis* and *S. yaculatensis*.

*Digestive system* (pl. 41, fig. 29).—On left side of animal. Stomach, in lower left half of body near ventral side-wall, possessing about thirty close, regular, ridges or folds. Esophagus somewhat less than half as long as stomach and joins latter at its posterior end. Long axis of stomach parallel with that of body. Intestine, immediately upon emerging from the pylorus, bends posteriorly and lies along upper half of stomach; it makes U-shaped bend anteriorly to form the rectal arm, which is about twice as long as the descending portion; anus with from six to sixteen blunt lobes. Inside the intestine, running its entire length, is a broad, fleshy fold that rolls up to form a tube. At the pylorus this expands into a bulb cleft on its surface. Running the entire length of the intestine is a clear, thin strip of wall about opposite the fold. In the stomach near the dorsal side is a foldless strip, the width of several folds. A larger and broader fold than the others borders this plain surface on one side.

*Reproductive system* (pl. 41, figs. 28, 29, and 31).—Ovaries much elongated, cylindrical masses, two on each side of the body; those on the right longer, extending nearly entire length of the body; those on the left considerably shorter. Of these latter the larger lies in the loop of the intestine and follows the rectum. The smallest ovary extends diagonally from the pyloric end of the stomach to end near its partner. Ovarian cylinders narrow down to short necks or oviducts near base of atrial siphon. Arranged along both sides of the elongated ovaries are series of testicular lobes, whose ducts unite on the midline of the inner surface of the ovary, and the common vas deferens thus formed ends as a papilla, a little short of the termination of the oviduct. The shape of the testicular lobes varies considerably, being simple and club-shaped in the younger individuals, but becoming bifurcate and irregularly branched in the larger ones.

*Breeding time*.—The summer months at least, in Monterey Bay. Observations on the point have not been made at other times and in other localities.

*Habitat and distribution*.—The littoral zone from British Columbia at the north to the southern limit of the United States at the south, according to present knowledge.

That this, one of the earliest known and most familiar ascidian species of Pacific North America, should have remained to this time without a detailed description is one of the vicissitudes in the progress of knowledge of our local marine fauna.

Although the specifications as to color in the diagnosis is the simplest statement that can be made, it would have to be much modified to make it apply to all individuals. Rarely if ever does it happen that a grown specimen is uniformly colored. The anterior part and one whole side of the animal are frequently more highly colored. Occasional specimens are almost devoid of the red color.

The flutings of the test are real structural differentiations and not mere folds, the test being much thicker in the ridges than in the

valleys. A cross-section of the ridges reveals, even to cursory inspection, the fact that the outer half, approximately, of the test-substance of the ridge is denser and more opaque than the inner part. This ease of sharp differentiation within the mass of a structure produced mainly by secretion should repay investigation.

Particular attention may be called to the fact so clearly brought out in the table, that the number of inner longitudinal vessels of the branchial sac, both on and between the folds, increases regularly and continuously with the increase in size, and hence presumably with the age of the animals.

Equally clear is it that the branchial tentacles also increase in number. This result corresponds with what was found by Ritter (1913) in several other species, but it is interesting to notice that certain differences in the mode of increase of parts in different species is indicated. For example, while the addition of new branchial tentacles in *S. montereyensis* is obvious for a large portion, at least, of the individual's life, this seems to be rather exceptional; for little or no increase in number occurs in *Halocynthia aurantium*, *Boltelia ovifera*, and *Styela macreteron*, species previously studied with reference to the same point.

Although the three stalked species of *Styela* occurring on the Pacific Coast of North America are well known to the senior author of this paper, two of them, *S. gracileyi* and *S. yacutatensis* having been described by him, until recently there has been some doubt in his mind about the specific distinctness of the three. But the studies of Huntsman and our own have removed the doubt.

It is noteworthy that this species, like several other ascidians, seems to flourish much better on the piles and other similar objects introduced into the water than on the natural shore rocks. The senior author has collected *S. montereyensis* from many points on the coast from San Diego to Mendocino, but has never seen a specimen of anything like maximum size growing on native rocks. The largest individuals seen were on the piles of the wharf at Santa Barbara; and at no other point has it been found in such abundance as there. However, it occurs in abundance and large size on the wharfs and breakwaters in the vicinity of Los Angeles.

**Styela gibbsii** (Stimp.)*Cynthia gibbsii*, Stimpson, 1864, p. 159.*Styela gibbsii*, Herdman, 1898, p. 261.*Styela gibbsii*, Ritter, 1907, p. 23.*Tethyum gibbsii*, Hartmeyer, 1909, p. 1359.*Styela* (sens. restr.,) *gibbsii*, Huntsman, 1911, p. 131.

This is one of the most widely distributed ascidians of the west coast of North America, it being now recorded from British Columbia to San Diego, and from the littoral zone to a depth of forty fathoms. On the coast of southern California it appears to be rare along shore, but fairly common down to a depth of forty to fifty fathoms.

**Styela barnharti**, n. sp.

Pl. 38, fig. 2; pl. 42, figs. 39 and 40

*Superficial characteristics*.—Roughly elliptical in outline, almost twice as long as broad, with branchial siphon sessile and directed anteriorly; atrial orifice a short distance below it on dorsal side. Each orifice 4-lobed and surrounded by four flattened, smooth mammillae corresponding to the lobes. Entire surface of the body mammillated with large rounded protuberances, except for the flattened disc of attachment (pl. 38, fig. 2). Test thick, firm, tough and semitransparent. Color reddish yellow, the red being most intense on the anterior end. Mantle strongly muscular, musculature consisting of longitudinal overlaid by weaker circular bands. Circular muscles most strongly developed in siphonal regions. Size of largest animal investigated: length 4 cm., diameter 2.25 cm.

*Branchial system*.—Branchial tentacles of several sizes, about forty. Atrial tentacles numerous, very small, slender, and tapering; in a single circle on inner surface of a narrow velum which is folded up against the wall of atrial siphon but not smoothly, the result being that the atrial tentacles are inserted in the bottom of a groove formed by a fold in the velum. The free edge of the velum and the rounded edge of the fold, between and beyond which the tentacles extend, are on about the same level. Spinules, each consisting of a single cell, occur on inner surfaces of siphons; rounded and toothed at their anterior ends with striations corresponding to the teeth on the dorsal surface; nucleus of the cell situated toward the posterior end. Spinules very similar to those of *S. montereyensis*. Dorsal tubercule horseshoe-shaped with ends curled inward. Branchial sac with four folds on each side. The distribution of the longitudinal vessels on the two sides for the large individual was:

$$\text{e'd's } \begin{cases} 6-16-9-14-6-11-8-15-6- & \text{R.} \\ 6-16-10-16-6-19-7-16-6- & \text{L.} \end{cases}$$

Transverse vessels of four orders and regularly arranged. Order of occurrence: 1-4-3-4-2-4-3-4-1; those of fourth order crossing the stigmata. Dorsal lamina a plain broad membrane.

*Digestive system.*—On left side of body. Esophagus (*e.*, pl. 42, fig. 40) emerges from dorsal posterior portion of branchial sac and curves into stomach, which is over twice as long as wide, and has about thirty-five longitudinal folds. Stomach lies along ventral and posterior portion of the animal; from its pyloric end the intestine runs anteriorly considerably past the middle of the body, then forms a loop and runs posteriorly parallel to itself and the stomach and to the left of the cardiac portion of the stomach, where it again forms a wide loop and runs anteriorly along dorsal portion of the animal, becoming somewhat convoluted just before reaching atrial orifice, where it ends in an anus bordering by many rounded lobes (pl. 42, fig. 40). Endocarps very numerous on intestine as well as on mantle.

*Reproductive system.*—Gonads probably nine in number on the right side and three on left side; those on the right in two groups. On the right side toward the dorsal surface are six parallel ovarian cylinders (*o.*, pl. 42, fig. 39). Of these the two middle ones are largest and seem to be continuous with each other at their posterior ends, although this may be due to crowding, as the glands were distended with ripe eggs. The two pairs of outside ovarian cylinders are less than half the diameter of the middle ones, all ending in tubular oviducts at their anterior ends somewhat below the atrial orifice. Just posterior to and partly concealed by the most ventral of these ovaries is a very small cylinder making the seventh of the group. Testicular lobes are thickly attached to the inner surfaces of the cylinders and their vasa efferentia join the vas deferens running along the center of each cylinder to end in a free tubular portion similar to and just back of the oviduct. The second group of two gonads of the right side is anterior to the group just described and transverse in position. The testicular lobes in this group extend considerably beyond the ovaries (pl. 42, fig. 39). On the left side the longest ovarian cylinder lies in the last loop in the intestine. The second longest one lies diagonally from the top of the first intestinal loop toward the atrial orifice. Between these two is a much shorter cylinder, ending in an oviduct located considerably farther back than the other oviducts (pl. 42, fig. 40).

One large specimen of this species was taken in July, 1915, from piles in San Diego Bay. Two small specimens were found in February on the carapace of a crab, *Rhodéa parvifrons*, taken at the end of the wharf of the Scripps Institution.

*Styela barnharti* belongs to the comparatively small section of the genus which have more than five gonads on a side. Its nearest of kin seems to be *S. elsa* Hartmeyer of the Japanese waters. So far as the gonads of the right side are concerned, *barnharti* and *elsa* appear to be considerably alike, the resemblance pertaining not only to the number but also to the disposition; for, according to Hartmeyer, those of this side form two groups. However, the anterior group in *elsa* contains three instead of two as in *barnharti*. But the similarity between the two species beyond this point is not close. In *elsa* the

gonads of the left side are as numerous as those of the right, though in the form of the digestive tract and the number of the internal longitudinal vessels the two are not widely separated. But in body form, character of the external surface, and number of branchial tentacles, as well as in the gonads of the left side, the two species are sharply separated.

Worthy of note is the fact that a majority of the *Styelas* having a high number of gonads apparently belong to the Pacific Ocean. But should more extensive study prove this to be actually so, the fact could hardly be considered as anything more than a coincidence. So far as we have been able to ascertain from the literature, the difference in thickness of the ovaries of the right side of *S. barnharti*, as shown in figure 39 of plate 42, is unique. It should be remarked that it is not due to difference in the stage of growth in the ova, these not being of recognizably different size in the larger ovaries. The meaning of this difference is not clear, but the fact that on the right side, where the number of ovaries is greatest, there are three distinct sizes, the smallest being relatively quite small, suggests that these smaller ovaries are in process of becoming rudimentary.

We take pleasure in naming this interesting *Stylca* for Mr. P. H. Barnhart, curator of the Scripps Institution, to whom we are indebted for all the specimens so far seen.

#### *Ascidia californica*, n. sp.

Pl. 38, fig. 6; pl. 41, figs. 24 to 27

*Superficial characteristics* (pl. 38, fig. 6).—Elliptical in outline but somewhat narrower anteriorly and quite depressed. Attached by the entire left side. Test thick, gelatinous, containing many anastomosing vessels, translucent but not sufficiently transparent to permit much of the internal organs to be seen; surface generally smooth and even. Siphons usually not prominent; the branchial directed forward and frequently somewhat to the right; the atrial located at half or a little more than half the animal's length toward posterior end on the upper surface but toward the left edge. The eight lobes of the branchial orifice are regular and somewhat long and pointed, with a brick-red pigment spot between the lobes. Lobes of the atrial orifice, almost invariably six in number, are bordered by a series of minute teeth; shorter and more rounded than the branchial lobes and similarly possessing pigment spots (*p.s.*, pl. 41, fig. 27). Largest specimen about 3.5 cm. long and twice as long as wide; usually smaller. Mantle thin and transparent on left or under side, with no muscle bands except in siphons and anterior part of branchial sac; on right or upper side muscle bands, running in all directions, form a thick pad.



*Branchial system.*—Siphons described above. Branchial tentacles very long and slender and of about the same size, varying in number, the larger individuals having as many as 150. Hypophysis (*hy.*, pl. 41, fig. 25), small and either oval or horseshoe-shaped with opening directed forward. Ganglion mass (*gl.*) separated by several times the length of hypophysis-mouth from the hypophysis (pl. 41, fig. 25). Dorsal lamina (*d.l.*) a broad membrane, broader posteriorly than anteriorly, provided with transverse ribs which project slightly past the edge; a few minute teeth between these projections. The lamina extends beyond the opening of the esophagus to the end of the sac. Branchial sac extends the entire length of the animal. Internal longitudinal vessels bear papillae at their intersections with the transverse vessels. In a large individual sixty internal longitudinal vessels and seventy transverse vessels were counted. No intermediate papillae present; ends of papillae curve toward the dorsal lamina and have a bulge on the concave surface. Plications in branchial membrane fewer than the longitudinal vessels. Meshes rectangular, a little longer than wide, each containing about three stigmata.

*Digestive system* (pl. 41, fig. 24).—On left side of branchial sac. About one-sixth of the branchial sac extends behind the digestive apparatus and about one-third in front of it. Mouth of esophagus about one-fourth the length of branchial sac from its posterior end. Esophagus sharply curved to enter the stomach. Stomach (*s.*, pl. 41, fig. 24) about twice diameter of intestine at its esophageal end, but gradually tapering to intestine at the other end; long axis at right angles to that of sac; wall with about twelve, wide, orange-colored, longitudinal folds. From the stomach the intestine runs anteriorly and then curves in such a fashion as to form the letter S reversed. Smooth-edged anus close to base of atrial siphon. A renal gland ramifies over the rectal limb of the intestine.

*Reproductive system* (pl. 41, figs. 24 and 26).—Peculiar widely branched ovary ramifies over whole inner surface of that part of intestinal loop which lies anterior to stomach. Testis lobes, much smaller and more finely branched than those of ovary, spread especially on inner surface of stomach and to some extent on both surfaces of intestinal loop. White vas deferens and oviduct run side by side along posterior side of rectum, the vas deferens lying between oviduct and rectum, both ending near the anus.

Specimens with sperm ducts enlarged and with eggs in their oviducts were taken in February at San Pedro, Santa Cruz, and La Jolla; in May at Half Moon Bay; in June at San Clemente, and in July at San Pedro.

*A. californica* belongs to the *Mentula* section of the genus *Ascidia*, this section being considered as characterized primarily by the extension of the branchial sac and dorsal lamina behind the esophageal mouth. But within this section it seems to be sharply set off from any species hitherto described. So far as we are able to ascertain, the fine pectination of the lobes of the atrial orifice (pl. 41, fig. 27) is entirely unique. The form and distribution of the ovary also con-

stitute good diagnostic features. In form, the ovary seems to resemble that of *A. aperta* Sluiter more than that of any other species; but the distribution of the lobes in the two is quite different, the broad, simple loop of the intestine of *aperta* making it impossible for the ramification to implicate so large a portion of the loop as it does in *californica*. But in most respects *aperta* and *californica* are very distinct.

*A. californica* probably resembles *Ascidia (Phallusia) ceratodes* Huntsman from the coast of British Columbia more closely than any other species, but from this it is distinguished by its smaller size, larger number of internal vessels, both longitudinal and transverse, smaller number of folds in the stomach, and most positive of all, more diffuse character of the ovarian lobes.

In view of the fact that the species is fairly common in the whole California littoral and seems not to occur much beyond this region, to the north, at least, we have felt that it is sufficiently typical of the region to merit the specific name *californica*.

*Habitat and range.*—On under sides of rocks at extreme low tide, the California coast from San Diego to Half Moon Bay (Mendocino County); also on kelp holdfasts (La Jolla) and "eel-grass" (Tomales Bay). Also to depth of thirty meters off San Diego.

From the material and data at our disposal the species seems to reach its best development at Santa Cruz.

*List of localities.*—San Diego region, almost everywhere, including San Diego and False Bays as well as points on the open coast, especially at La Jolla; Laguna Beach; San Pedro; San Clemente Island; Monterey Bay; mouth of San Francisco Bay; Tomales Bay. But at none of the stations except in Monterey Bay, at Santa Cruz, has it been taken in large numbers massed together in the fashion characteristic of many ascidian species.

*Type locality.*—La Jolla.

### **Cheylosoma productum** (Stimp.)

*Cheylosoma productua*, Stimpson, 1864, p. 161.

*Cheylosoma productum*, von Drasche, 1884, p. 281.

*Cheylosoma productum*, Baneroft, 1898, p. 309.

*Cheylosoma productum*, Huntsman, 1911, p. 124.

The prevailing size and elevation of specimens of this species, occurring on the California coast, are so much less than similar dimensions of animals from Puget Sound, the type locality, as to seem almost to justify the recognition of a subspecies for the southern forms. However, neither the detailed anatomical studies by Baneroft (1898)

nor the examinations made later by several observers have succeeded in finding any constant structural characteristics on which to base such a group; and as both size and height are subject to much variation it appears best, on the whole, not to give our forms a separate name. Specimens are not infrequently taken in the littoral zone, but are more common in depths of a few fathoms.

#### ***Ciona intestinalis* (L.)**

*Ascidia intestinalis*, Linn., 1767, p. 1087, no. 3.

*Phallusia intestinalis*, Sav., 1816, p. 169.

*Ciona intestinalis*, Flemming, 1828, p. 468.

*Ciona intestinalis*, Roule, 1884, p. 13.

*Ciona intestinalis*, Hartmeyer, 1903, p. 297.

(For an exhaustive bibliography, see Hartmeyer, 1903.)

We have subjected specimens from San Diego Bay to a thorough-going comparison with the descriptions and figures of Mediterranean specimens given by M. Roule in his well-known monograph of 1884, and find nothing to suggest even a race distinction for the west American animals. Indeed, the perfect identity and the fact that the species appears to be distributionally restricted in this region almost entirely to localities frequented by ships, leads one to wonder if it is not an immigrant to these parts. This surmise is the more warranted by the habits of the animal, it being especially given to clinging to the under sides of floats, buoys, and the like. In these situations it flourishes most luxuriantly and occurs in enormous numbers. We would not however, make too much of this suggestion as to distribution, since the species has been reported (Huntsman, 1911, and Ritter, 1913) from a rather wider range in Pacific waters than is altogether consistent with this theory. *Ciona* is sexually ripe in San Diego Bay through the later summer, the entire autumn, and to mid-winter at least; probably ripe animals may be found throughout the year.

#### ***Metandrocarpa dura* (Ritter)**

*Goodsiria dura*, Ritter, 1896, p. 150.

*Metandrocarpa dura*, Michaelson, 1904, p. 70.

Although this species is not very often taken in its original habitat, it is still one of the most conspicuous of our ascidians—this from its favorite habit of forming incrusting masses on various of the larger seaweeds, which, though usually growing below tide, are often washed up decorated with the bright red colonies.

**Metandrocarpa michaelsoni, n. sp.**

Pl. 38, fig. 8; pl. 39, fig. 14; pl. 42, figs. 41-45

*Superficial characteristics* (pl. 38, fig. 8).—Zoooids appearing as rounded mounds, the larger ones averaging about 4 mm. in diameter through base and from 2 to 3 mm. high; never embedded in a common test but probably always a film of test passing between them; adherence to substratum, usually the under side of rocks, very close. Color bright, cherry-red to hardly more than a tinge of that color; cherry far more common. Siphons short and always deeper red than body. In large colonies, which may be half a square foot in extent, zoooids come to be close together, almost covering the substratum, but these irregularly distributed with no intervention of common test. Blastozoids seem always to move away some distance, three, four, five or more millimeters and a delicate trail of test with a strand can be made out connecting bud and parent (*t.t.*, pl. 39, fig. 14). Large, numerous ectodermal vessels in test film around blastozoid (*c.p.*, pl. 39, fig. 14).

*Zoooids*.—Test thick, tough, and not transparent. Mantle with many circular and longitudinal muscle fibers. Body rests on its left and ventral side with its anterior or disc shifted toward right and dorsum so as to bring branchial orifice to top of mound (pl. 42, fig. 42); length about 3 mm.; consisting of large branchial sac with digestive and reproductive organs on the sides.

*Branchial system*.—Siphons fairly close together in central portion of the upper surface of mound and very little elevated above general surface; orifices not bordered by definite lobes. Branchial tentacles from thirty to forty, alternating long and short (pl. 42, fig. 43). About twenty very small atrial tentacles (pl. 42, fig. 44). Branchial sac at most with nine rows of stigmata; four or five internal longitudinal vessels on each side; largest individuals always with five on each side; very fine transverse vessels cross most of stigmatic series midway between the primary vessels. Much pigment in blood cells throughout branchial sac as in other tissues of animal. Number of stigmata about thirty in each half series. Table 2 shows the distribution of the stigmata in five individuals.

TABLE 2

Indiv.	Side	1st space	2d space	3d space	4th space	5th space	6th space	
1	{ L.	6	6	6	5	3	5	} D. L.
	} R.	6	6	5	3	3	8	
2	{ L.	6	5	4	3	2	4	} D. L.
	} R.	6	5	4	4	3	7	
3	{ L.	7	6	5	4	5	0	} D. L.
	} R.	6	4	3	4	2	6	
4	{ L.	6	5	4	4	4	0	} D. L.
	} R.	5	6	3	3	3	4	
5	{ L.	7	5	5	3	3	5	} D. L.
	} R.	6	5	6	4	3	5	

Dorsal lamina, a plain fold growing wider and thicker posteriorly. Hypophysis a single elliptical opening just anterior to the elongated ganglion (*hy.* and *g.g.*, pl. 42, fig. 43).

*Digestive system* (pl. 42, figs. 41 and 42).—Situating on left posterior half of branchial sac. Esophagus (*e.*, pl. 42, fig. 41) emerges from dorsal posterior part of branchial sac. Stomach wider than long, its wall thrown into twelve to seventeen looped folds of varying lengths depending on their position; eight of these folds heading around the esophagus, the others, shorter, on opposite sides of organ, point toward a seam constituting a part of the cardiac end of stomach. A sac-like caecum (*c.*, pl. 42, fig. 41) on stomach near end of seam, joined by a fine duct to pyloric gland which ramifies over intestine (*p. gl.*, pl. 42, fig. 41). Intestine emerging funnel-wise from stomach, regularly S-shaped, the dorsal half of the S twisted nearly to a right angle with ventral half (*int.*, pl. 42, figs. 41 and 42); a narrow, thin strip of epithelium running along entire convex side of intestine; anus with a thickened bilobed margin, situated in atrial chamber near atrial orifice.

*Reproductive system* (*o., t.*, pl. 42, fig. 41).—Gonads in form of "polycarps" attached to mantle on both sides of body. About three ovaries anteriorly situated on each side of endostyle (*o.*, pl. 42, fig. 41). About five testis masses (*t.*, pl. 42, fig. 41) on right side in a row along the endostyle; on the left side usually four or five masses arranged around end of intestinal loop. From the summits of male gonads extend short vasa deferentia into the peribranchial cavity (*v. d.*, pl. 42, fig. 45).

*Breeding habits*.—Embryos and advanced tadpoles retained in peribranchial chamber; breeding during midwinter months.

This species, the name of which we are glad to make stand as a testimonial to Dr. Michaelsen's good work on this group of ascidians, is rather sharply distinct from *M. dura* Ritter, its neighbor in habitat, as well as in a number of structural features. While *dura* never, so far as our observations go, departs much from the completely aggregated and fused type of colony (Ritter, 1896, especially figures 1 and 2, pl. 12), the colony of *michaelseni* seems never to assume this form. Not infrequently the zooids of the middle portion of the colony of *michaelseni* are so close together as to be nearly or quite in contact with one another. This seems to arise entirely from the intercalation through budding of new zooids and never from the approximation of the buds in the new parts of the colony. The trailing off of zooids in these parts of the colony as shown in figure 14 of plate 39, is entirely characteristic of this species. This difference may depend upon the difference in habit of the two species, *dura* growing typically on seaweeds where, as a consequence, the room for expansion of a given colony is limited, while *michaelseni* is almost if not quite restricted to the surfaces of rocks and molluscan shells. As to the zooids themselves, the most positive difference is in the number of series of stigmata, *dura* having twelve and *michaelseni* nine.

*Habitat and distribution.*—Typically the under sides of rocks in littoral zone on rocky shores everywhere on coast of southern California and probably, though not certainly, as far north as San Francisco, at least.

*Type locality.*—La Jolla.

### **Polyzoa translucida, n. sp.**

Pl. 38, fig. 7; pl. 42, figs. 36 to 38

*Superficial characteristics of the colony.*—Composed of zooids joined by short strands to a basal network and, in older colonies, with individuals so close together that considerable portions of the tests of neighboring zooids adhere to each other. Zooids generally roughly egg-shaped although in the largest individuals the two siphons on anterior end may be quite prominent. Zooids colorless and semi-transparent (pl. 38, fig. 7).

*Zooids.*—Largest 5 to 6 mm. long and 3 to 4 mm. thick. Tests tough, but thin and transparent. Mantle with numerous fine longitudinal and transverse muscle fibers. Body consisting of large branchial sac with digestive and reproductive organs located at side; on each side about opposite the third stigmatic series, an elliptical sac-like body attached to mantle, probably corresponding to the endocarps of styelids (*cn.*, pl. 42, figs. 36 and 37).

*Branchial system.*—Branchial siphon 4-lobed, located in middle of anterior end. Atrial siphon also 4-lobed, near branchial siphon on dorsal side of anterior end. Branchial tentacles about thirty, alternating long and short. Atrial tentacles about twenty, very small. Branchial sac without folds, with twelve rows of stigmata, each having from thirty to forty stigmata in a half-series; three longitudinal vessels on each side; greatest number, about fourteen, of stigmata between endostyle and first longitudinal vessel; about eight stigmata in each of remaining intervals. In largest individual fine longitudinal vessels cross the stigmatic series midway between the primary vessels (pl. 42, figs. 36 and 37). Endostyle narrow. Dorsal lamina a plain membrane rolled into a tube. Hypophysis a slit-like opening just in front of ganglion.

*Digestive system.*—Situated on left side and posterior half of branchial sac. Esophagus (*c.* pl. 42, fig. 36) about equal in length to stomach; emerging from branchial sac near its dorsal edge, removed about two stigmatic series from its posterior end. Stomach (*s.*, pl. 42, fig. 36) considerably broader than long, made up of eleven or twelve prominent folds shorter on side turned away from sac. A section of intestinal tract consisting of the esophagus, stomach, and a portion of the intestine about as long as the esophagus, lies in a horizontal position; organ then bends and runs parallel to its previous course nearly to the dorsum of animal, where it turns anteriorly a short distance and ends in the bilobed anus. In wall of intestine is a narrow strip running its length, thinner than the rest of the wall and free from pigment, which is seen to be a groove when viewed from within the cavity of the intestine. A caecum from near pyloric end of stomach is joined by a fine duct to a pyloric gland which ramifies over intestine (pl. 42, fig. 36).

*Reproductive system.*—Gonads hermaphroditic "polyearps," those on right disposed in row along the endostyle, as many as twelve in large individuals; on left about five, situated near endostyle in anterior half of sac (*o.* and *t.*, pl. 42, figs. 36 and 37). In large individuals peribranchial cavities contain numerous eggs and larvae. In such cases the large oviduct forms a conspicuous portion of hermaphroditic gonad (*ov. d.*, pl. 42, fig. 38). A small tentacle-like sperm duct terminates the male gonad near oviduct (*v. d.*, pl. 42, fig. 38).

*Habitat and distribution.*—So far as known, only from wharf piles in San Diego Bay where it occurs interwoven with hydroids and other animals which inhabit the piles. The only specimens were taken in June.

Although the presence of eight internal longitudinal vessels on the branchial sac is held to be a generic character in *Polyzoa*, we cannot believe that the much smaller number in *translucida* ought to bar it from the genus, so well does it agree with the other more important generic characters.

#### **Botryllus tuberatus**, n. sp.

Pl. 39, figs. 10 and 12; pl. 40, fig. 22

*Superficial characteristics of the colony.*—Thin, encrusting, usually not more than 3 or 4 cm. in expanse and 1 to 2 mm. in thickness. Number of zooids in circular systems varies between three and ten; systems close together. Zooids usually black from pigment although variations occur, and colonies with comparatively little pigment are found. Zooids of a system communicate with common atrial orifice by long, spout-like siphons (*a.s.*, pl. 40, fig. 22); openings of siphons varying from small and oval in younger zooids to large and gaping in older ones; edges of upper portions of openings unite to form the common cloacal orifice, lower lips often extending a little beyond the cloacal orifice, so as to be visible through it from above (pl. 39, fig. 12). At intervals along margin of colony occur exceedingly dense, pedunculated bunches of ectodermal ampullae, each ampulla having its own long ectodermal vessel running into body of colony; young zooids often occurring among the ectodermal ampullae (*c.a.* and *y. z.*, pl. 39, fig. 10); the ectodermal vessels generally branch and send out smaller, less darkly pigmented ampullae. Test gelatinous and transparent.

*Zooids.*—Length about .8 mm. General shape cylindrical but curved, concave side being dorsal; length a little greater than width. Mantle strongly pigmented, and containing a few widely separated extremely delicate longitudinal muscle fibers (pl. 40, fig. 22).

*Branchial system.*—Sac cylindrical, a little longer than broad; four series of stigmata; three longitudinal vessels on each side; about fourteen stigmata in each half-series; usually three stigmata in spaces between longitudinal vessels and four between endostyle and its adjacent vessels, and four between dorsal lamina and its adjacent vessels; stigmata five or six times as long as broad. Endostyle wide and straight. Dorsal lamina a plain membrane rolled into a tube. Sixteen small branchial tentacles of which the eight larger ones alternate with eight very small ones.

*Digestive system.*—Situated on left side and posterior end of branchial sac. Stomach longer than broad, and tapering toward esophageal end, its long axis being horizontal and its lower edge about even with lower edge of sac; its wall thrown into seven distinct longitudinal folds; a tubular caecum attached to stomach near its posterior end and upper side (*c.*, pl. 40, fig. 22). Intestine tapers from stomach and almost immediately makes a sharp bend and runs dorsally parallel to and above stomach; upon reaching dorsal edge of body, it turns anteriorly for a short distance; anus situated in lower part of atrial chamber.

*Reproductive system.*—No reproductive organs were seen in the colonies investigated. The fact that the specimens were collected in January and December may account for this. Very young zooids had two great protruding buds, one on each side. In young zooids the atrial orifice is similar to the branchial but takes on the spout-like character as the animal matures.

*Habitat and distribution.*—So far as known, *B. tubercatus* is confined to the coast of southern California. No Botryllid has yet been seen north of Point Conception. The type locality of this species is Santa Barbara, and the specimens taken there were on the leaves of kelp, *Macrocystis pyrifera*. Despite much search in the kelp beds off San Diego, the animal has not been found there. At La Jolla the species occurs in considerable abundance at times on rocks at extreme low tide. This difference in habitat and the fact that the San Diego specimens are, at least in some cases, much more deeply pigmented than those from Santa Barbara and usually devoid of the peculiar tube-like masses of ectodermal ampullae, have caused us to hesitate much as to the propriety of regarding them as belonging to the same species. However, the absence of differences in the zooids of the colonies from the two localities, the well-known color variation in the genus, and the presence of small and somewhat protruding clusters of ampullae on a few specimens from points midway between Santa Barbara and San Diego have led us to follow the more conservative course and treat all the specimens as of the same species. Should future study prove this to be unjustifiable, the San Diego form should be the basis for another species.

The great pedunculated masses of ampullae are sufficient in themselves to set *tubercatus* off sharply from the other species of the genus.

### ***Botrylloides diegensis*, n. sp.**

Pl. 43, figs. 46-49

*Superficial characteristics of the colony.*—Flat, incrusting, irregular in outline; may be several centimeters in expanse with a thickness of 5 mm. Color in life varying from pinkish yellow to purple. Systems elongated; number of zooids in a system variable, ten to fifteen occurring in the older systems; islands of test (*i. t.*, pl. 43, fig. 49) in the colony surrounded by zooids give impression of systems; atrial orifices not found. Ectodermal vessels and ampullae numerous near margins of colony and in island of test; ampullae oval, and black from accumulation of pigmented cells.



*Zooids*.—Cylindrical, standing vertically in test; length 2.5 mm., width about 1 mm.; length of languet and size of atrial orifice varies depending upon position of zooid in system; atrial orifice often wide and gaping. Mantle thin, with feeble musculature, only a few circular and longitudinal bands occurring near branchial and atrial orifices, but pigment very abundant. Alimentary organs and stigmata easily seen through mantle if some of pigment is removed with strong alcohol (pl. 43, figs. 46 and 47).

*Branchial system*.—Branchial orifices large and circular, projecting slightly above surface of colony. Branchial tentacles sixteen, symmetrically arranged. Tentacles next to endostyle and lateral ones at a quadrant's distance from this longest, with enlarged pigmented bases, insertion deeper in the siphon than the others. Dorsal tentacle, inserted just above the hypophysis, long but its pigmented base not as large as in the others; alternating with the major tentacles, four tentacles about half as long; and finally alternating with the eight large and medium-sized tentacles, eight very short ones (pl. 43, fig. 48). Twelve series of stigmata in the branchial sac with about fourteen stigmata in a half-series; three internal longitudinal vessels on each side; two or three stigmata in a mesh except next to the dorsal lamina where there are from four to six. Dorsal lamina a plain straight membrane, wider toward the posterior end of the body. Endostyle large, conspicuous, straight. Neural gland situated over anterior end of dorsal lamina just outside peripharyngeal band; duct of gland opening conspicuously on surface of the oval dorsal tubercle (*hy.*, pl. 43, fig. 48).

*Digestive system*.—Stomach (*s.*, pl. 43, fig. 46) seeming to consist of nine or ten large drawn-out loops, these being clustered at esophageal end and from thence tapering back to pyloric end; loops concentrated on right side, only three reaching around on left side so that the latter presents a plain space from which a sac-like caecum (*c.*, pl. 43, fig. 46) is given off toward the intestine where it connects with a pyloric gland located on that organ; posterior to branchial sac and toward right side of body. Esophagus emerging from branchial sac at its posterior end near dorsal lamina; about as long as stomach, inserted into a depression surrounded by rounded ends of gastral loops. Intestine on left side and posterior end of branchial sac, bending abruptly forward and dorsalward a short distance behind the stomach; anus on dorsal side of branchial sac about midway the length of the zooids; two narrow, thin, non-pigmented strips on opposite sides of intestine extend whole length of rectal portion. Rectum somewhat compressed, strips placed at edges of compression; strip along outer convex side of intestine broader (pl. 43, fig. 46).

*Reproductive system*.—One ovary and one spermary on each side of posterior half of body, these appearing as conspicuous protuberances, the spherical ovary especially prominent when containing a nearly mature ovum (*o.*, pl. 43, fig. 47); lobulated spermary anterior to ovary of same side; ovary and spermary of left side farther forward than those of right.

*Habitat and distribution*.—The species occurs in great abundance on piles, floats, etc., in San Diego Bay, but so far has not been taken elsewhere, though it will undoubtedly be found at other points on the coast of southern California at least.

*B. diegensis* appears to be more like *Botrylloides purpurcum*, Herd. (Herdman, 1886) from near the Philippine Islands than any other species. The conspicuous gastric loops are, however, quite distinctive of *diegensis*. Furthermore, *purpurcum* is described as presenting a lobing of the mantle at the branchial aperture which does not occur in *diegensis*. Again, the transverse musculature of the mantle of *purpurcum* is considerably stronger than that of *diegensis*.

### *Perophora annectens* Ritter.

*Perophora annectens*, Ritter, 1893.

*Perophora annectens*, Huntsman, 1911, p. 118.

A careful study of the asexual reproduction and relation of the zooids in the colony in *P. annectens* relative to its geographic distribution and general habits of life ought to be made; for nowhere in its range, as it now seems, excepting in central California, do the colonies reach the complete "compound ascidian" condition described for some specimens by Ritter, 1893. Although the species is by no means rare on the southern coast, we have never found it in any such abundance as that in which it occurs at Pacific Grove, and the zooids are always, so far as our observations have gone, quite distinct from one another. Huntsman (1911) reports the same to be true of specimens from the coast of British Columbia.

### *Distaplia occidentalis*, n. sp.

Although *D. occidentalis* has already figured to a considerable extent in writings on ascidians, notably in the paper by Baneroff (1899), it has always appeared, so far as taxonomy is concerned, as a manuscript species by Ritter. But since neither diagnosis nor species-figure have been published hitherto, its career as a known species ought to date from the publication of this paper, and Ritter and Forsyth recognized as responsible for it (pl. 45, figs. 64 and 65).

*Superficial characteristics of the colony.*—Either flat and erecting, or pedunculated and mushroom-shaped with all gradations between; flat, from 3 or 4 mm. thick and several centimeters in expanse; pedunculated forms varying from 2 mm. to 1 cm. or more across flattened heads, peduncles being of same length or longer; flat form often pedunculated at margins of colonies. Systems plain, several in a head; zooids closely arranged around a large, cylindrical, lobed, common atrial orifice, which extends considerably above the general

surface as a delicate-walled short pipe. Color light green, variable, dark brown, cadmium-yellow, brick-red, dirty white. Test consisting of a thin, tough outer layer covering the less resistant inner portion, both having many bladder cells; ectodermal vessels running parallel with long axis of peduncle and not branching or anastomosing.

*Zooids* (pl. 45, fig. 64).—Small, from 2 to 3 mm., average of twelve individuals 2.5 mm. Mantle delicate, containing many diagonally running muscle fibers; two strong dorsal longitudinal muscle bands extending from the vicinity of branchial siphon to the esophagus, causing branchial sac to shrink along dorsal sides in preserved specimens. The atrial languet long, but varying in shape and size depending on position of zooid in colony; one or three-lobed.

*Branchial system*.—Branchial siphon large with six broad blunt lobes. At base of siphon sixteen tentacles, four placed symmetrically at the quadrants of circle, much larger; alternating with these, four about half as long; finally alternating with the eight, eight very short ones (pl. 45, fig. 65). Branchial sac with four series of stigmata; the most posterior series having the longest stigmata, those of the other series gradually shorter in order; the stigmata long and slender, about twelve in a half-series; each series crossed by a delicate intermediate transverse vessel which does not interrupt stigmata; in young individuals stigmata become gradually smaller toward endostyle, leaving triangular spaces between series and main transverse vessels. Dorsal languets three, about half the length of the stigmata, located a little to left of mid-dorsal line.

*Digestive system*.—Esophagus about equal in length to stomach and very slightly twisted. Stomach inflated in appearance, egg-shaped, long in proportion to its breadth; smooth on outer surface, slight, discontinuous, branching ridges generally longitudinal on inner surface, giving it a reticulated appearance; long axis of stomach forming a slight angle with long axis of zooid. On emerging from stomach, intestine runs ventrally for a distance equal to width of stomach, then bends anteriorly and maintains a straight course until it ends as a lobed anus near the middle of branchial sac. Ramifying over the intestine from the pylorus halfway up to anus is the pyloric gland (*p. gl.*, pl. 45, fig. 64). Within intestinal loop is a clear bulb which is part of this system; this connected with stomach by a fine duct (pl. 45, fig. 64).

*Reproductive system*.—Testicular lobes and ovary on right side of intestinal loop in young individuals, but in adults ovary always posterior to loop and testis largely so, though owing to its great size it may extend beyond the loop in both directions; testicular lobes all communicating with the vas deferens at one point by delicate vasa efferentia; the vas deferens running along intestine nearly to the anus. Oviduct a thin-walled tube lying immediately over the vas deferens, bending to enter incubatory pouch at right dorsal posterior corner of branchial sac. Incubatory pouch (*i. p.*, pl. 45, fig. 64) containing two or three eggs, very rarely four; larvae present in colonies taken in June and July; absent in colonies taken in January.

*Habitat and distribution*.—On rocks in littoral zone from San Diego to Puget Sound, common in many places.

*Type locality*.—San Diego, California.

As pointed out by Bancroft (1899), *D. occidentalis* is easily distinguishable from all the other species of the genus, with the possible exception of *D. rosea*. There seems, however, no doubt about the distinctness of these two. Although the color of *occidentalis* is so varied that not much reliance can be placed upon it for taxonomic purposes, yet since rosaceous is one shade that seems not to occur in *occidentalis*, the color distinction is worth something. The most positive differences between them so far as recognized are the absence in *rosca* of internal vessels crossing the stigmata; the smaller number, usually twelve, of stigmata in a half-series in *occidentalis*; *rosca* having, according to Herdman, from twenty to thirty; and the presence on the inner surface of the stomach wall of *occidentalis* of the network of low but distinct ridges.

*Color*.—Examination of an abundance of colonies by the senior author at Point Conception in January, 1908, some of which were nearly white while others were brick-red, led to the supposition that the red color was an old-age mark. There was ample evidence of degeneration in the red colonies, but not in the light ones. But besides the degenerated zooids in the red colonies, there were also many partly grown ones, indicating that the colonies were undergoing degeneration and regeneration simultaneously. On the whole the zooids of the light-colored colonies were considerably larger than those of the red ones, though partly grown zooids were also present in the light colonies. The pigment of the red colonies was confined to the test. No larvae were found in any of the animals at this time.

*Embryogenesis*.—The escape of the larvae from the parents and their behavior during their brief existence before becoming attached were observed by the senior author on July 24, 1896. The young are retained in the parent until the tadpoles are fully formed. They emerge from the common cloacal orifice posterior end foremost. Their exit is entirely passive, the egg membrane being still intact and the larva's tail closely folded around the body. Frequently the individuals are shot out with considerable force. So far as could be ascertained by watching the escaping larvae, they are forced into the common atrial chamber by muscular contraction of the individual parent zooids, and are then expelled to the outside by a contraction of the common chamber. The exact nature of this second phase of the expulsion is not clear and merits study, particularly as to the mechanism by which it is accomplished.

Immediately upon reaching the outside world most of the larvae

fall inertly to the bottom, though an occasional one escapes from the egg membrane and swims with a wriggling motion immediately on emerging from the parent. Although the larvae have a free swimming period, this is very short. It lasts but a few hours at the most, nor is the swimming executed during the period sufficiently vigorous and determinative to make it count for much if anything in the distribution of the species. In view of the very brief swimming period in the larval life of this and of several other species of Ascidians, the general question of the significance of larvae in the group becomes of interest and suggests a systematic study of the point.

Bancroft (1899) describes some interesting features of the reproductive system of *Distaplia occidentalis*, from which we quote:

The most striking peculiarity of the oviduct is that its diameter, even when distended by the passage of the ovum, is very much less than the normal diameter of the ripe egg. Accordingly, when the egg is passing through the duct, it is greatly distorted, assuming the shape of a sausage.

With regard to the incubatory pouch he says:

A careful examination of the structure of the pouch shows that it is not merely a diverticulum from the peribranchial sac, but consists of two parts which, for descriptive purposes, may be called the oviduct and the peribranchial portions, though I do not know that they have been developed from the oviduct and peribranchial sac respectively. The oviducal part is a narrow tube, the anterior end of which connects with the oviduct, and the posterior end with the bottom of the pouch. Anteriorly the peribranchial portion is a narrow tube opening into the posterior dorsal corner of the right peribranchial sac. Posteriorly, it is enlarged to form the pouch proper, in which the developing embryos are lodged. The oviducal portion of the pouch is a continuation of the oviduct into the pouch, and the egg never reaches the peribranchial sac at all, but is conveyed directly to the bottom of the pouch. . . . As the pouch is completely separated from its zooid long before the larvae are mature, the only function of this peribranchial orifice is to serve as a passage of the spermatozoa.

Our observations, as reference to plate 45, figure 64 will show, confirm Bancroft's account of the incubatory pouch, but leave the question as to the exact method by which the eggs get into it unanswered.

The two species of the old genus *Distoma* treated in this paper belong to Caullery's subgenus *Eudistoma*.

#### **Eudistoma psammion, n. sp.**

Pl. 44, figs. 52 and 53

*Superficial characteristics of the colony.*—Massive, though encrusting; hard, largely because of much sand in deeper layers of test; thickness in thickest part about 2 cm.; not thin in any part; expanse

several centimeters but extremely variable. Considerable sand adhering to tougher surface layer but a stratum of test just beneath freer from sand than other parts. Color varying from brown to brown with a distinct tinge of claret. Zooids in systems with about eight animals in a system; common cloacal orifices on small rounded elevations regularly distributed over surface.

*Zooids.*—Not thickly crowded and apparently at different levels in the test, perhaps due to shrinkage; consisting of thorax and abdomen, a slight constriction at base of branchial sac marking separation. Abdomen containing intestinal loop, reproductive organs, and heart; from two to four times as long as thorax (pl. 44, fig. 52). Length of zooid from 4 to 5 cm. in shrunken preserved condition. Muscle bands of mantle in two strong sheets (*m.b.* and *m.b'.*, pl. 44, fig. 52) on right and left sides of body and extending its entire length; on both sides the longitudinal muscles stronger than the transverse; the portion of mantle free from muscle fibers often puckered between muscle sheets. The visceral organs protrude, hernia fashion, through this less resistant portion of mantle, especially when reproductive organs are at their fullest development. Ectodermal processes (*e.p.*, pl. 44, fig. 52) borne at posterior ends of zooids, two or three times length of body.

*Branchial system.*—Siphons long and tubular, each 6-lobed; the atrial usually longer than the branchial, situated on dorsal side of branchial sac, often some distance from its anterior end; remoteness of the zooids from common cloacal orifice in the systems accounts for long "goose-neck" character of the atrial siphon (pl. 44, fig. 53). Branchial tentacles of different sizes, about thirty in number, scattered over the surface of siphon instead of being in a circle. Branchial sac with three series of stigmata and ten stigmata in a half-series. Endostyle usually very convoluted, doubtless due to shrinkage. Dorsal languets two, short and blunt.

*Digestive system.*—Consisting of long loop occupying entire length of abdomen; plane of loop extending from right to left of zooid. Emerging from greater part of posterior end of branchial sac is the large, long esophagus which enters stomach (*s.*, pl. 44, fig. 52) located past the middle of abdomen. Stomach somewhat flattened from right to left and straight to outline across posterior end; remaining outline a regular curve, except for a depression located anteriorly into which the esophagus enters. Stomach wall smooth on outer surface, fairly thick; granular on inner surface. Intestine proper differentiated into three distinct parts: the first a little longer than the stomach, enters an enlarged second portion of about the same length, having firm thick walls, and entering the rectal limb of the loop by a narrow tubular constriction; third is the rectal limb, the first portion of which is enlarged and firm-walled for a distance equal to all the preceding intestine; anus at about level of posterior one-third of atrial chamber. The two arms of the intestinal loop almost parallel throughout their course (pl. 44, fig. 52).

*Reproductive system.*—Ovary and testicular lobes on dorsal side of intestinal loop and when fully developed, so voluminous as to make zooid flask-shaped (*t.*, pl. 44, fig. 52). Eggs develop in atrial cavity and become almost as large as branchial sac and produce a great protuberance.

*Breeding season.*—June and July. Colonies collected in these months had large eggs in the atrium while in colonies taken in January the ovarian eggs were still small.

*Habitat and distribution.*—In the littoral zone, usually on the underside of rocks. According to our present information extending from San Diego to Dillon's Beach near the mouth of Tomales Bay. The species has been taken on the rocks north of the Scripps Institution, La Jolla, though not in abundance.

*Type locality.*—La Jolla, California.

### ***Eudistoma diaphanes*, n. sp.**

*Superficial characteristics of the colony.*—Flat and encrusting, soft, usually even surfaced and regular in outline. Rarely exceeding 10 cm. in greatest expanse, usually much smaller; seldom if ever more than 1 cm., frequently only a few millimeters thick. Color varying from white to pale vermillion; test transparent, containing a great quantity of cellular material but no bladder cells or spicules; almost entirely free from sand.

*Zooids.*—Uniformly distributed; not disposed in systems; inconspicuous by reason of small size and meagerness of pigment; placed at various angles to surface of colony. Length about 3 mm.; less in preserved condition. A distinct capsule of test enveloping each zooid. Mantle musculature similar to that of *Eudistoma psammion*. Ectodermal processes present but not as long and numerous as in *E. psammion*.

*Branchial system.*—Siphons relatively shorter than those of *E. psammion*, the two of about equal length; both opening on surface. As far as could be made out, branchial sac very similar to that of *E. psammion*. Branchial tentacles about twenty in number, of two sizes, not all in same circle but scattered somewhat over surface of siphon.

*Digestive system.*—Similar to that of *psammion* but violent contraction often obscures similarity.

*Reproductive system.*—Similar to that of *psammion*. Specimens from La Jolla collected in July had large eggs in atrial cavity.

*Habitat and distribution.*—On under side of rocks in littoral zone from San Diego to San Francisco, according to our present knowledge.

*Type locality.*—La Jolla, California.

These two species of *Eudistoma* are quite similar as far as the zooids are concerned; but the striking differences in the colonies, and the fact that *E. diaphanes* does not have systems, and hence its two siphons are of about equal length is our basis for recognizing two species.

The senior author has more or less carefully examined specimens presumably of *Eudistoma diaphanes* from many points on the California coast between Cape Mendocino and San Diego. Unquestionably much variation occurs within the range, particularly in the size and color of the colonies, and it is by no means impossible that more

exhaustive collecting and more extensive comparative studies will find that the animals living farther to the north are specifically distinct from those of the south on which we are chiefly relying for the establishment of the present species. In connection with the description of *Distoma lobata* from Puget Sound, Ritter (1900) remarks upon the similarity of *lobata* to a *Distoma* "widely distributed on the California coast." The species occupying us is one of the group of Californians to which reference was made in this quotation.

These two *Eudistomas* furnish a good case of coincident distribution of two closely related species. That they are very much alike as far as the zooids are concerned is obvious; and so far as we know there is nothing at all differential in their habitats. However, we would not be too positive on this latter point. Wider and more detailed knowledge of the range of both may bring to light habit differences which we do not now recognize.

If Ritter (1900) is right in supposing the zooids of *D. lobata* to possess five instead of three series of stigmata, the two closely allied California species now before us seem to be considerably less similar to the Puget Sound species than to *E. plumbium* Della Valle, a Mediterranean species. *E. diaphanes* in particular has much in common with the European species; but *diaphanes* differs from *plumbium* according to our present knowledge, in the larger number of branchial tentacles, in the relatively longer esophagus, and probably in the sharp division of the post-gastric intestine into sections.

#### ***Didemnum carnulentum*, n. sp.**

Pl. 39, fig. 11; pl. 44, figs. 57 to 59

*Superficial characteristics of the colony.*—Thin and encrusting and of considerable expanse, often half a foot or more; thickness 4 mm. or less. Color typically the pink of the human skin but varying to opaque white. Position of the zooids indicated by small spots caused by accumulation of spicules; these spots often appearing in double rows which surround islands of gelatinous-appearing semitransparent test and giving surface a reticulated appearance (pl. 39, fig. 11). Spicules varying in diameter from .19 to .075 mm., their blunt rays springing from a spherical nucleus (pl. 44, fig. 59); confined mainly to uppermost stratum of colony. Bladder cells, usually polygonal from mutual pressure but free from spicules, make up lower layer of test. Branchial sacs of zooids embedded in upper spicule-bearing stratum, their abdomens extending about halfway down into bladder-cell stratum. Upper stratum of test having spaces in it which seem to serve for communication with the common cloacal orifices, zooids not being arranged with any reference to these openings. Cloacal



orifices comparatively few in number and large; branchial orifices small openings in center of spots caused by closely set spicules.

*Zooids* (pl. 44, fig. 57).—From 1 to 2 mm. long, depending upon thickness of colony; made up of thorax and abdomen. Mantle with no muscle fibers visible. Color orange.

*Branchial system*.—Branchial siphon with six distinct, usually pointed lobes, located in middle and anterior part of branchial sac. Atrial siphon a plain round opening on dorsal side opposite middle of sac. Branchial sac with four series of stigmata, each having about six in a half-series; stigmata elliptical. Endostyle proportionately very broad. Dorsal languets three. Branchial tentacles eight, very small. Two strong muscle bands from dorsal part of branchial sac continue to near the recto-esophageal collar where they terminate in a free process (*m.b.*, pl. 44, fig. 57).

*Digestive system*.—An elongated loop with arms closely applied but open at bend. Esophagus (*c.*, pl. 44, fig. 57) proportionately large, emerging from middle posterior part of branchial sac; often as much as three times the length of sac. About two-thirds of its length from sac, esophagus bound to rectum by a band (*c.c.*, pl. 44, fig. 57). Stomach (*s.*, pl. 44, fig. 57) almost globular with smooth surface; its long axis slightly inclined to that of zooid. First part of intestine, about equal in length to stomach, connected by a portion equally long but of smaller diameter with rectal arm of loop; anus very near atrial opening.

*Reproductive system*.—Large undivided testis situated on left side of intestinal loop; on its rounded mound-like surface is the coiled vas deferens (*v.d.*, pl. 44, fig. 57), coil having six turns. Ovary, usually containing one large egg and several very small ones, located between stomach and testis (pl. 44, fig. 57); ripe eggs almost as large as branchial sac. No oviduct appears to be present and how eggs are discharged is not definitely known. Large tadpoles found in the test of some colonies. Budding the same type as that which will be described below for *Trididemnum della vallei*.

*Breeding season*.—Colonies containing many tadpoles in June, but few or none in January and February.

*Habitat and distribution*.—In littoral zone but never at limit of high tide; usually on under sides of rocks. Abundant at La Jolla and on all rocky beaches of the San Diego region. Although this species has not been found at any other point, in all probability this is due to insufficient collecting.

*Type locality*.—La Jolla, California.

The specific name refers to the prevailing flesh color of the living colonies.

#### *Didemnum carnulentum* var. *lacteolum*

Pl. 40, fig. 23; pl. 44, fig. 60

*Superficial characteristics of the colony*.—Enerusting and very thin, never of the great extent of *Didemnum carnulentum*; 1 mm. and less in thickness. Color pure white, due to numerous calcareous spicules varying in size from .15 to .065 mm. (pl. 44, fig. 60); spicules

very numerous in lowermost stratum of colony, zooids extending into both upper and lower limy strata. Bladder cells not conspicuous but present around closely packed zooids. Zooids very similar to those of *Didemnum carnulentum* but smaller. The atrial orifice proportionately much larger, often over half the length of branchial sac. Testis almost spherical when fully ripe and half as large as sac. Coil of vas deferens contains seven turns. Ripe ova gigantic, even larger proportionately than in *carnulentum*. Budding similar to that of *Trididemnum della vallei*. Breeding season in June.

*Habitat and distribution*.—On under sides of rocks in the littoral zone and in the holdfasts of kelp, hence from depths of a few fathoms. Common at La Jolla and in the San Diego region.

The variety or sub-species here recognized differs from the typical species in color chiefly, it being opaque white. We do not, however, depend on this difference exclusively for recognizing a group that deserves a separate name. The other differences that seem significant are in the character of the atrial orifice, this being considerably larger in *lactolum*; and in the spicules, these being blunter in *lactolum*. Possibly significant, too, is the fact that what we are regarding as a variety lives typically in the great masses of kelp holdfasts, at a depth, consequently, of several fathoms.

The species and variety of *Didemnum* here described have much in common with several previously described species; but of their distinctness from all those that have been treated with sufficient detail to enable us to judge, there seems little doubt.

It appears almost incredible that the one hundred species, more or less, of *Didemnum* now recognized, can all be really distinct. Yet we cannot assume that specimens from a geographical region as remote as ours from other regions which have furnished the known species, are the same as any that have been named but not described with sufficient definiteness to enable us to make sure of the identity of ours with these. There seems no course open, therefore, but to add still another to the list of supposed species.

A thorough revision of this group of ascidians based on ample material of all recognized species is much to be desired.

The milk-whiteness of the colonies suggested the name..

### ***Trididemnum della vallei*, n. sp.**

Pl. 44, figs. 54 to 56

*Superficial characteristics of the colony*.—Encrusting on the under surfaces of rocks, colonies being half a foot or more in expanse in some cases; thickness from 1 to 2 mm. Color gray with tinge of yellow.

Common cloacal orifices large and comparatively few, scattered among the numerous zooids. Test immediately around cloacal openings free from spicules. Spicules of usual *Didemnum* type but differing from those of *D. carniculatum* in that the rays are distinctly longer and relatively slenderer (pl. 44, fig. 56); size from .2 mm. to .08 mm., confined mainly to surface layer of test, but sparingly present throughout. Usually in preserved specimens branchial orifices marked by white spots due to accumulation of spicules; these spots uniformly and thickly scattered over surface of colony without definite arrangement with reference to the cloacae. In expanded condition six branchial lobes showing as clear oval spots in middle of each lobe near its base. No bladder cells observed in test.

*Zooids* (pl. 44, fig. 54).—Length 1 mm. or less; divided into thorax and abdomen, the two being equal in size; esophagus and rectum girdled by a constricting band about midway the length of zooid (pl. 44, fig. 54); placed at all angles to surface of colony. Ectodermal processes, (*e.p.* pl. 44, fig. 54) given off from mantle near stomach, extending for varying distances into test, ending in pigmented swellings. Mantle very thin and delicate, a few weak, longitudinal and horizontal fibers being visible over branchial sac.

*Branchial system*.—Branchial siphon with six distinct lobes; atrial orifice plain, at the end of a tubular siphon which protrudes from middle of dorsal side; its sphincter muscle strong and distinct. Three series of stigmata, about ten orifices in first series, eight in second, and seven in third; considerable area of unperforated branchial membrane at both ends of sac. Endostyle straight and proportionately very broad. Two dorsal languets placed at intervals between stigmatic series. Two muscle bands in branchial sac, one on each side of mid-dorsal line, course ventralward toward posterior end of sac and, meeting each other behind sac between esophagus and endostyle, are carried out into a blunt process with an epithelial covering, this process penetrating into the test (*m.b.*, pl. 44, fig. 54). Endostyle often arched at both ends in preserved specimens, due to contraction of these muscles. Branchial tentacles equal in length, variable in number, twenty being found in one zooid; about sixteen the usual number (pl. 44, fig. 55).

*Digestive system*.—A loop in which the esophageal and rectal limbs are closely applied, loop being wide and nearly circular. Recto-esophageal collar almost midway the length of the esophagus. Stomach almost globular, smooth-walled. First part of intestine, a little shorter than stomach, tapering from large pyloric opening; connected by a piece of about equal length but of much smaller diameter to rectal arm of loop; this latter of greater diameter than middle piece; anus opposite atrial orifice (pl. 44, fig. 54).

*Reproductive system*.—Single conical mound-shaped testis situated on bend of intestinal loop on left side; coil of vas deferens containing six turns. The ovary, apparently consisting of single egg when ripe as large as branchial sac; but in reality a small number of minute ova always present. No oviduct found and the mode of escape of eggs not known; the relatively enormous eggs (fully half the size of full-grown zooids) after escape from ovary, scattered through test at rather regular intervals in layer immediately in contact with the sub-

stratum. Budding abundant in some colonies. (See section on this subject at end of description.)

*Period of egg-production.*—January.

*Period of budding.*—July.

*Habitat and distribution.*—Under sides of rocks in the littoral zone at La Jolla and in the San Diego region; Dredging Station II off San Pedro, depth six meters.

*Type locality.*—La Jolla, California.

This species seems to resemble *Trididemnum* (*Didemnum*) *strangulatum* Ritt. as closely as any other but is well separated from it by the shorter stigmata, unlobed atrial orifice, and presence of the muscular process at the posterior end of the branchial sac.

We are glad to name this species, a study of the budding of which has received considerable of our attention, after Professor Della Valle, whose work on budding in this group is distinguished.

*The budding* is very similar in this species to that described later on in detail for *Diplosoma pizoni*. As seen in plate 44, figure 54, the budded intestinal loop grows out just beneath the recto-esophageal collar from two sources, the mother esophagus and the mother rectum. Likewise the budded thorax is connected to the same two sources of the mother zooid posterior to the budded intestinal loop. The supposition that a division takes place so as to give the mother thorax the newly budded intestinal loop and the budded thorax the old intestinal loop is supported by the fact that many zooids were seen with large thoraces and small intestinal loops and *vice versa*.

#### *Diplosoma pizoni*, n. sp.

Pl. 43, figs. 50 and 51; pl. 45, figs. 66 to 68

*Superficial characteristics of the colony.*—Exceptionally soft, encrusting, several centimeters in expanse; thickness about 3 mm. Color of preserved specimen mottled light and dark gray; closely set zooids easily seen through transparent test. Common cloacal orifices few in number, large and chimney-shaped. Each zooid surrounded by thin layer of test and joined to lower surface of colony by a strand of about the same length as zooid. The test consisting of upper and lower thin layers, and strands surrounding zooids joining these layers, containing great spaces between and among zooids; many small colorless cells and fewer but much larger round pigmented cells; but no bladder cells.

*Zooids.*—About 1.5 mm. long, consisting of thorax and abdomen. Mantle containing much dark pigment especially over stomach and intestine, the epithelial layer here consisting of large, flat, polygonal cells with small, round, clear nuclei usually near one end of darkly pigmented cell body (pl. 43, figs. 50, 51); adheres closely to surround-

ing test. Muscle fibers in transverse vessels and two strong bands on each side of dorsal lamina coalescing at posterior end of branchial sac into a band that continues posteriorly through test strand nearly to lower surface of colony. A few ectodermal vessels with enlarged extremities present on ventral side of zooid in angle between sac and intestine (*e.p.*, pl. 43, fig. 50).

*Branchial system.*—Branchial siphon plainly 6-lobed; atrial orifice a great opening usually longer than half the branchial sac and extending at least halfway across sides of sac. Branchial sac with four rows of stigmata, each containing seven or eight large stigmata in a half-series. Three tentacle-like dorsal languets. Branchial tentacles sixteen, of three sizes, and symmetrically arranged so that the four largest alternate with the four or second size and finally the eight smallest alternate with the eight larger ones.

*Digestive system.*—Intestinal loop twisted and turned up at a right angle to long axis of zooid so that reproductive organs, belonging typically to right side, become located at posterior end of zooid. Short esophagus given off from posterior dorsal part of branchial sac; stomach globular, smooth-walled; portion of intestine immediately following stomach and about equaling it in length connected by a piece of less diameter to a rigid bulbous portion at beginning of rectal arm; rectum oblique; anus situated less than half the distance up branchial sac. Pyloric gland (*p.gl.*, pl. 45, fig. 68) and its bulbiferous duct well-developed.

*Reproductive system.*—Situated on right side of intestinal loop, but bend of intestine brings gonad to posterior of zooid. Testis conical, two-lobed, the vas deferens emerging from between the lobes. Ovary usually containing one large egg and a few small ones (*o.*, pl. 43, fig. 50). Ripe discharged eggs and embryos scattered thickly on lower layer of test, the eggs apparently making their way down through the strand of test to reach this position; eggs observed at different levels in these strands seeming to support this theory (*ov.*, pl. 44, fig. 50). Tadpoles probably break through test and escape into common atrial cavity and pass out through common atrial openings.

*Habitat and distribution.*—Known only from San Diego Bay where but a single colony has yet been taken, this having been found on piles.

*D. pizoni* is undoubtedly very close of kin to *D. listeri*, but there is hardly a doubt about their specific distinctness. *Listeri* has bladder cells in the tests; *pizoni* has not. *Listeri* has ten stigmata in a half-series, while *pizoni* usually has seven and seems never to have more than eight. The stomach of *pizoni* is more spherical than that of *listeri*, it being figured as heart-shaped in the European species.

*Asexual reproduction in D. pizoni.*—The larva of this species presents the same aspects as those pictured and described by Salensky and Caullery for *Diplosoma listeri*. In the diplosomic larva the zooid and blastozooid are distinguishable here as there, the former being characterized by its vascular appendages and pigmented larval sense

organ. The opinion of Caullery (1895) and Pizon (1905) is that the double larva is due to precocious budding; and this view seems unescapable from our observations. Pizon (1905) has so fully described all stages in the budding of *Diplosoma listeri*, from which the course of things in our species varies but little, that the barest outline is all we have thought necessary to give.

Various stages of bud development in the colony were observed in this species. Examining plate 45, figure 66, one sees that the new intestine (*b.i.*) arises from two sources. The new esophagus comes from the mother esophagus and the new rectum is joined to the mother rectum. According to Pizon, who watched growing colonies in all stages of development, a bud from the mother esophagus produces a new esophagus, stomach, and intestine, and these curl around to meet and join a little rectal bud from the mother rectum. The budded branchial sac and rectum (*b.b.*) likewise arise from two sources. The budded esophagus is joined to the mother esophagus and the new rectum is joined to the mother rectum. According to Pizon, the branchial sac is formed from the epicardium and its accompanying rectum grows from a bud on the mother rectum up into place alongside the new sac. Plate 45, figure 67 shows at *d. i.* the degenerating piece of intestine the disappearance of which severs the intestine of the budded zooid (*b.b.*) from the intestine of the mother zooid (*m.s.*). After the break there are two zooids in one of which the original mother branchial sac (*m.s.*) has the newly budded intestinal loop and the newly budded branchial sac (*b.b.*) has the old original intestinal loop (*m.i.*).

#### *Diplosomoides caulleryi*, n. sp.

Pl. 40, fig. 21

*Superficial characteristics of the colony.*—Thin, encrusting, and comparatively firm; thickness about 2 mm.; expanse several centimeters. Color of preserved specimens dark gray sprinkled with white calcareous spicules. Zooids numerous, each branchial orifice 6-lobed, light colored, circular. Common atrial orifices few, large, rounded or elongated, flush with surface; test immediately around them free from spicules. Spicules fairly numerous and evenly scattered in surface of test. Little test immediately around branchial sacs, this stratum of colony being cavernous; lower stratum, containing abdomens of zooids and large eggs, more continuous and solid. Spicules sparingly scattered throughout test between bounding layers; somewhat resembling the large round test cells to which they are about equal in size.

*Zooids*.—Length about 1.5 mm., consisting of thorax and abdomen (pl. 40, fig. 21); long axis of abdominal loop usually continuous with that of thorax, though often flexed laterally; mantle adhering very closely to test. A few ectodermal vessels (*c.p.*, pl. 40, fig. 21) with club-shaped extremities present just anterior to stomach and toward ventral side of zooid, always in close proximity and just ventral to budded branchial sac.

*Branchial system*.—Branchial orifice with six small pointed lobes. Atrial orifice a great opening extending almost the length of sac and reaching halfway across sides; atrial languet present, large and scoop-shaped. Branchial sac with four series of stigmata each containing eight stigmata in a half-series; dorsal languets three, very slender. Branchial tentacles very slender, about sixteen, of different sizes, not arranged in any regular order.

*Digestive system*.—Esophagus emerging from central portion of posterior end of branchial sac, about one and one half times as long as stomach, curved. Stomach smooth-walled, globular-elliptical. Intestine consisting of a piece immediately following stomach, large in diameter and about equalling stomach in length; then a shorter connecting piece of smaller diameter, situated at lowest part of loop; next a large, smooth-walled, bulbous portion; finally the rectal arm of about same diameter as esophagus, lying about parallel with stomach and esophagus. The smooth-edged anus situated just opposite middle of posterior series of stigmata.

*Reproductive system*.—Testis (*t.*, fig. 21) double, the two parts forming rounded protuberances on right side of intestinal loop; vas deferens arising between lobes and running along side intestine, vas deferens arising between lobes and running alongside intestine. Ovary an elongated sac between stomach and rectum; the small ovarian eggs arranged in a row. It would seem that the ovarian sac allows eggs to escape by rupture since in some colonies large eggs studded the lowermost layer and apparently had no connection with zooids.

*Budding*.—Intestinal and similar to that described for *Diplosoma pizoni*. In this species esophagus of budded sac joins mother zooid very close to junction of mother esophagus and stomach.

*Habitat and distribution*.—Known only from upper part of San Diego Bay, near National City.

The combination of characters in this species makes difficult its inclusion in any of the numerous genera that have been created for ascidians of the *Didemnum* type. In fact, as the family Didemnidae has been defined by some authors, e.g., von Drasche (1883) and Van Name (1910), it would be excluded from the family by its possession of a straight vas deferens according to both these authors, and by its atrial languet according to Van Name. We, however, agree with Hartmeyer (1909) that the definition of the family ought to be sufficiently elastic to admit this species. It seems to us that in the general character of the colony, especially in its being hardened by the possession of calcareous spicules and still more in the type of budding

its closer affinity to the Didemnidae through *Trididemnum* than to the Polycitoridae through *Distaplia* is undoubted. Having decided that it belongs to the Didemnidae, the question as to what genus of that family it should be assigned remains to be decided. Accepting the genera of the family recognized by Hartmeyer (1909) only two of the nine of these, *Didemnum* and *Polysyncraton*, are regularly characterized by the possession of an atrial languet, and in both of these the testis is single-lobed and the vas deferens is coiled; so it does not seem possible to regard our species as belonging to either of these genera. All things considered, we conclude that the species can be placed in *Diplosomoides* Herdman with less violence than in any other recognized generic group. In all respects other than that of its atrial languet, *caulleryi* conforms very well to the characterization of this group; and we think Hartmeyer (1903) justified in redefining *Diplosomoides* as to include species which, like his *D. dubium*, possess an atrial languet. The languet of *dubium* is much shorter than that of *D. caulleryi*, and the difference between the two may be taken, as we have contended in discussing the structure in *Amaroucium*, as indicating its modernness and, perhaps for this reason, undependableness for the characterization of genera.

We take pleasure in naming this especially interesting species after Professor Caullery, whose observations on the reproduction of various species of the Didemnidae has contributed so much to our knowledge of the remarkable phenomena here presented.

### **Glossophorum planum, n. sp.**

Pl. 39, fig. 13; pl. 46, fig. 71

*Superficial characteristics of the colony.*—Larger colonies pumpkin-seed shaped, smaller ones spherical, all having short, thick, cylindrical peduncles; outline regular, surface smooth, free from sand or other foreign substances; systems distinct and regular, zooids plainly seen through test; common cloacal orifices open and very distinct even in preserved specimens (pl. 46, fig. 71). Color grayish brown, much the same in living and preserved specimens. Length of about maximum-sized colony 10 cm., width 5 cm., thickness 1.5 cm. The test consisting chiefly of a well-defined central core into which zooids do not extend; small in quantity among zooids; matrix semicartilaginous and transparent, but containing a great number of very small pigmented cells which impart to it a somewhat dirty tinge; portions among zooids containing scattered, rather small bladder cells; central core thickly penetrated by thin-walled transparent stolons to which zooids are always attached.



*Zooids*.—Numerous, distinctly seen through test, arranged in very regular systems, on an average about a dozen individuals in a system, occasionally as many as twenty, in a system. The three regions of body, thorax, abdomen, and postabdomen, distinctly set off from one another, making it difficult to extract zooids entire; never much contracted; little pigment matter in tissue; musculature very feeble; mantle thin and transparent; entire structure easily made out by examining animals *in situ* in slices of colony. Length of zooids about 4.5 mm.; length of branchial sac about 3 mm.; postabdomen slightly longer than abdomen; musculature very weak. About sixteen delicate longitudinal muscle bundles extending from branchial siphon backward to terminate about midway the length of branchial sac; a few delicate encircling fibers in branchial siphon; stronger fibers constituting a sphincter muscle around atrial orifice.

*Branchial system*.—Branchial orifices easily seen on surface of colony; each with six broad scallops when fully expanded, but becoming pointed lobes upon contraction. Atrial orifice overarched by a long broad languet often truncated but sometimes with three delicate terminal lobes; size and shape of languet depending upon age of zooid and its position in system. Tentacles eighteen to twenty-six, of three lengths, the six longest nearly as long as the half-diameter of circle in which they are situated. Number of series of stigmata from thirteen to seventeen; about thirteen or fourteen very regular stigmata in each half-series; number of series as well as number of stigmata increasing with age of zooid; a small muscle band in each interstigmatic vessel; papillae on interstigmatic vessels regular in size and arrangement, there being one for the interval between every two stigmata. Dorsal languets very regular, one for each interstigmatic vessel. Endostyle narrow and straight. Atrium exceptionally large and well-defined.

*Digestive system* (pl. 46, fig. 71).—Small in proportion to size of branchial sac; lateral flexure of intestinal loop pronounced, the antero-posterior axis of stomach being brought nearly to a right angle with the long axis of branchial sac. Esophagus emerges from dorsal posterior angle of branchial sac and bends abruptly ventrally to a right angle to enter the smooth-walled stomach which is slightly asymmetrical and a little longer than broad. Intestine usually divided into three portions; first, the part immediately behind stomach which is a little longer than stomach and has a bulge about midway of its length; next, a connecting piece that lies on left side and enters enlarged rectal limb by a very small, short, cylindrical tubule; and third, the long rectal piece having two blunt caeca on each side of proximal end. Rectum runs first parallel with stomach, then passes to left of esophagus and ends in a constricted anus a little less than half way up branchial sac.

*Postabdomen* elongated, pear-shaped, connected with abdomen by a narrow peduncle near intestinal loop; containing but little mesenchymatous tissue, and a large and distinct heart (*h.*, pl. 46, fig. 71) situated in its posterior end.

*Reproductive system* (*o.* and *t.*, fig. 71).—Not voluminous, situated in postabdomen about midway of its length, compact, the testicular lobes (*t.*) and ovary (*o.*) closely intermixed; vas deferens (*v.d.*) con-

spicuous, passing around left side of intestinal loop to right side and following rectum to end near the anus; its last portion swollen when filled with sperm. Tadpoles develop in atrium.

*Habitat and distribution.*—Species widely distributed on California coast, it having been found at almost every point where ascidian collecting has been done, from Mendocino to San Diego. It is confined to rocky localities, but not to the littoral zone, judging from the frequency with which it is washed ashore. To what depths it extends is not known as it has never been taken by dredge or trawl.

At San Diego it occurs on the United States Government breakwater at the entrance of the bay; also on the breakwater at Coronado. In these localities it is not confined to the under surfaces of rocks, but grows on their tops and sides.

*Type locality.*—San Diego, California.

This species is undoubtedly closely related to *Glossophorum humile* Lahille; but the following differences seem fully to establish the specific independence of the two: *G. humile*, according to Lahille, is entirely covered with fine sand, while our species is peculiarly free from sand. The colony of *G. humile* is relatively thinner than that of *G. planum* and no mention is made by Lahille of a peduncle of *G. humile*. The atrial languet is pointed in *G. humile* while it is usually broadly truncate in *G. planum*. There are about twenty stigmata in a half-series in *G. humile* while fourteen is the highest number found in *G. planum*. According to Lahille and Herdman, *G. humile* possesses sixteen tentacles; never less than eighteen have been found for *G. planum*.

Perhaps no species of compound ascidian in our fauna is so well adapted for laboratory demonstration as is this, and since it is fairly abundant and obtainable with little difficulty, it should be useful in this way.

### **Macroclinum par-fustis**, n. sp.

Pl. 38, fig. 3; pl. 45, fig. 63

*Superficial characteristics of the colony.*—Sand-encrusted, consisting of a few or numerous club-shaped masses each having a peduncle usually about twice as long as the more or less rounded head; masses connected together in colony by a stolonial basal network (pl. 38, fig. 3). Length various, the largest colony investigated 6 cm. long, with head 2 cm. long and 1.5 cm. thick. On smaller heads one common cloacal orifice present in center of anterior portion; on larger heads several such orifices occur, each surrounded by about twelve zooids. Branchial orifices indicated by slight, sand-covered elevations in preserved specimens. Test gelatinous and transparent, containing many small test cells scattered throughout its substance. Surface layer tougher and usually thickly embedded with sand grains.

*Zooids*.—Consisting of thorax, abdomen, and postabdomen; thorax a little longer than abdomen; total length about 1 cm.; long post-abdomen terminating in an elongated granular mass, probably stored-up nutrient material. Mantle very thin with numerous delicate longitudinal muscle bands extending entire length of animal; circular fibers in branchial siphon and a few irregular ones in mantle over upper part of branchial sac.

*Branchial system*.—Branchial orifice with six blunt lobes; atrial with flat truncated languet ending in three lobes (pl. 45, fig. 63). Branchial tentacles about thirty, of three sizes. Branchial sac with sixteen series of stigmata, from twenty-five to thirty stigmata in a half-series; a small space near the endostyle free from stigmata; stigmata next to endostyle smaller than others of a series. Endostyle straight and narrow. Dorsal languets with flattened bases which run into transverse vessels upon which they are situated, about as long as stigmata in anterior part of the sac, becoming a little longer and heavier toward posterior end of series.

*Digestive apparatus*.—Esophagus emerging from middle of posterior end of branchial sac, about equal to stomach in length. Stomach roughly cylindrical, a little longer than wide, with a seam on left surface; wall granular on its inner surface, but not folded. Intestine extends posteriorly from stomach for a distance about equal to length of stomach, then makes a loop and after running parallel to stomach crosses esophagus on left side and ends in a bilobed anus less than halfway up atrial chamber. In base of loop intestine narrows abruptly to enter rectal arm between two blunt caeca (c., pl. 45, fig. 63).

*Reproductive system*.—Gonad a pyriform elongated mass just behind intestinal loop, the numerous testicular lobes composing the great bulk of it; usually one well-developed egg and several much smaller ones, yellow in preserved specimens, situated in anterior of gonad, surrounded by testis lobes.

*Habitat and distribution*.—*M. par-fustis* is known from rocky shores at La Jolla, Santa Monica, and Pacific Grove; and from Dredging Station LIX, off San Pedro, in twenty-eight meters water.

*Type locality*.—La Jolla.

The name is derived from Latin *fustis*, a cudgel. The systematic position of this and the next species, *M. pellucidum*, is by no means clear. *M. par-fustis* might be placed in the genus *Psammaphidium*, its resemblance to *P. retiforme* Herdm., one of the species of this genus with a smooth-walled stomach, being close. However, on the basis of the single character, the sandiness of the test distinctive of *Psammaphidium*, it would be necessary to assign *par-fustis* and *pellucidum* to different genera, a course which in our judgment would be unjustifiable in view of the very close resemblance of the two so far as the zooids are concerned.

All things considered, we conclude that *Macroclinum* Verr. as redefined by Hartmeyer (1903) is the generic group with which our

species is most akin. According to this revised definition, the only difficulty in the way of this disposition of the species is the breaking-up of the colony of both *par-fustus* and *pellucidum* into club-shaped masses. In view, however, of what occurs in the various other allied genera, this difficulty can hardly be regarded as serious. What may be of more importance as touching the integrity of *Macroclinum* is the discovery by Van Name (1910) that the inner surface of the stomach of *M. pomum* (SAR), which should be the type species of the genus, is areolated. This fact raises the question of whether further study may not make it advisable to retain the genus *Aplidiopsis* Lah., which Hartmeyer has assumed to be synonymous with *Macroclinum*, for the smooth-stomached species. Should this turn out to be so, *par-fustus* and *pellucidum* would be transferred to *Aplidiopsis*, for there is no trace of areolation in the stomachs here.

#### **Macroclinum pellucidum, n. sp.**

Pl. 39, fig. 9; pl. 45, fig. 62

*Superficial characteristics of the colony.*—Pyriiform with peduncle as long as and often longer than globular portion; entire length about 1.5 cm. Anterior surface somewhat flattened with one large, centrally located, common atrial orifice; around this usually three to six branchial orifices; branchial orifices 6-lobed; common atrial orifice indistinctly 12-lobed. Colony colorless and transparent, making zooids distinctly visible through test; test tough on outer surface and only thin partitions between zooids within (pl. 39, fig. 9).

*Zooids.*—Occupying greater part of globular portion of colony, though unusually contracted in preserved specimens. Branchial sacs often broken loose at orifice and forced out through opening by shrinkage of colony. Thorax, abdomen, and postabdomen each about 3 mm. long. Mantle with about twelve wide, longitudinal muscle bands on a side, these separated by spaces several times wider than bands; bands running together just below branchial sac; lodged in a depression on ventral side of zooid between arms of intestinal loop, and continuing posteriorly into peduncle, where they disappear in a large lobe of granular material, probably accumulated food (*m.b.*, *f.m.*, pl. 45, fig. 62).

*Branchial system.*—Branchial siphon indistinctly 6-lobed; atrial with flat, truncated languet having usually three or four lobes. Branchial sac with eleven series of long, narrow stigmata, about twenty in half-series; most posterior series having longer stigmata than others; stigmata of last series gradually shorter toward end-style; in younger zooids number of series less than eleven, stigmata at the ends of a half-series small, oval, gradually becoming longer toward middle of series. Dorsal languets long and flat, with broad flat bases which merge into membrane of transverse vessels upon which

they are situated; as long as the stigmata in anterior part of sac, and increasing in length toward posterior end. Endostyle much convoluted, doubtless due to shrinkage. About twenty closely set, branchial tentacles of three sizes.

*Digestive system.*—Esophagus emerges from dorsal posterior part of branchial sac and makes a short curve to enter large, globular, smooth-walled stomach. Stomach with long axis almost horizontal, asymmetrical by entrance of esophagus on median line of under side. Plane of intestinal loop placed nearly at a right angle to sagittal plane of zooid; anus about halfway up branchial sac (pl. 45, fig. 62).

*Reproductive system.*—Ovary and testis closely associated; mostly on dorsal side of intestinal loop when immature, but extending behind it in maturity. Testicular lobes numerous and surrounding the comparatively few eggs located in anterior part of gonad. Tadpoles found in atrial cavity in July.

*Habitat and distribution.*—Known only from La Jolla, where it occurs on rocky shores between tides. Only one lot of specimens has so far been found. The almost glass-like transparency of test of animal in life has suggested the specific name. For remarks on the systematic position of this and the preceding species, see under *M. par-fustis*.

#### **Amaroucium californicum, n. sp.**

Pl. 46, fig. 72

This species has been referred to several times in papers by the senior author as a MS. species by Ritter; but in the absence of a diagnosis or a figure hitherto published, from now on it should be assigned to Ritter and Forsyth.

*Superficial characteristics of the colony.*—Exceedingly irregular, usually encrusting, variable in the thickness even in same colony; frequently lobulated, in some cases pedunculated. Very variable in size, often reaching an expanse of from 10 to 20 cm.; thickness varying from .5 to 2 or 3 cm., even in same colony. Never encrusted with sand, but sand sometimes scattered through deeper portions. Color various, from opalescent white to reddish brown.

*Zooids.*—Usually very numerous; frequently, though by no means invariably, distinctly visible through test, both in living and preserved colonies. Systems sometimes present, distinct; sometimes absent, the same colony at times showing both conditions. In an encrusting colony from San Diego jetty, the systems very plainly oval when zooids were few in number but became elongated as number of zooids increased. These zooids were orange-colored especially anteriorly; buried in the clear, colorless, transparent test, systems separated on the surface by whitish, almost opaque, elevated ridges. In another colony devoid of systems, the individuals were light brown, set in the still lighter, opalescent, gelatinous test. Still another colony was opalescent white, individual zooids opaque white. Rarely large, not often exceeding 6 mm. in length, usually shorter, only a few zooids observed whose long, slender postabdomens brought them near to 1 cm.

in length; consisting of thorax, abdomen, and postabdomen, marked off from each other by slight constrictions; thorax and abdomen usually about same length. Musculature consisting of about fifteen longitudinal muscle bands on a side, extending into postabdomen where they are closer together and stronger; usually considerable pigment in mantle.

*Branchial system.*—Branchial orifice with six well-developed lobes; atrial without lobes, but having a long, tapering, pointed languet. Branchial sac with eight to fourteen series of stigmata, ten seemingly most common; about twelve stigmata in a half-series. Endostyle narrow and straight. Dorsal languets, one to each transverse vessel, placed to left of a clear strip of sac free from stigmata; about as long as stigmata and gradually increasing in length toward posterior end of series. Branchial tentacles short, blunt, about ten, somewhat irregularly scattered.

*Digestive system.*—Plane of intestinal loop transverse to median plane of zooid; esophagus large and almost twice the length of stomach; stomach cylindrical, about as wide as long, with longitudinal folds each presenting a loop turned toward anterior end of stomach; folds sometimes branching or discontinuous, making the number variable for different colonies, twenty-two and fourteen being the average for a large number of zooids. Intestine divided into three divisions; anus not quite halfway up branchial sac.

*Postabdomen and reproductive system.*—Varying greatly in length, short in young zooids. Testicular lobes (*t.*, pl. 46, fig. 72) in two rows, right and left. Ovary situated a short distance behind intestinal loop just anterior to testicular lobes, much less voluminous than the latter. Larvae retained in atrial chamber till a late stage of development.

*Breeding season.*—June and July, at least.

*Habitat and distribution.*—*A. californicum* is probably the most common ascidian on the California coast. It occurs on rocks, usually on the under sides, at all points where collecting has been done, and is found everywhere on piles, floats, breakwaters, etc., except in the upper portions of bays where the density and temperature of the water are distinctly different from normal sea water. Dredgings do not indicate that it flourishes in depths beyond a very few fathoms. It also occurs at Puget Sound (Ritter, 1900), and, with some doubt, on the Alaskan coast as far to the north and west as the Shumagin Islands (Ritter, 1901).

*Type locality.*—San Diego.

Although *A. californicum* possesses no strikingly distinctive characteristics, is very variable and has a wide distribution, it cannot be identified with any hitherto described species. Its closest relative appears to be *A. glabrum* Verrill of the north Atlantic coast of North America. The detailed examination of *A. glabrum* and also of the allied species *A. pellucidum* by Van Name (1910) enables us to make a pretty satisfactory comparison of *californicum* with these species.

To the general form of the colony of *californicum*, the reverse of

the statement made by Van Name for *glabrum* may be applied. Concerning the Atlantic species he writes: "The tendency to irregular and individual variation in the shape of the colony is considerable, but nearly all the shapes are readily recognized as modifications of the capitate form above described." For *californicum* we might transcribe this sentence, but with the word "capitate" changed to "encrusting." Undoubtedly the typical colony of *californicum* is flat and cake-like, but deviations from this in various directions are numerous.

As to the zooids, the following differences seem to be differential: the average number of stigmata, twelve, in a half-series in *californicum* is so much fewer than the number, eighteen, given for *glabrum*, as to leave no doubt about the distinctness in this point. The number of folds in the stomach wall is also undoubtedly sharply different in the two species. As our table 3 shows, the folds of the *californicum* stomach vary widely in number, the lower limit being fourteen and the upper limit twenty-two; and a cursory inspection of the table reveals that the prevalent number is much nearer the upper than the lower limit. Concerning the folds of *glabrum*, Van Name says: "The stomach has as a rule a rather small number, 12 to 15, of deep longitudinal folds; but in some colonies the number averages higher, about 18 or 20 or even more." An exhaustive statistical comparison of the two species would be interesting, but there is little question as to what, in general, the result would be. Further, the sharp division of the loop of the intestine into a portion of large and smaller diameter found in *californicum* must be wanting or nearly so in *glabrum*, judging from Van Name's figure. There are probably minor differences in the lobings of the branchial and atrial orifices, but this point requires further examination.

TABLE III

FOLDS IN THE STOMACH WALL OF DIFFERENT ZOOIDS OF THE SAME COLONY OF  
*Amaroucium californicum*

Colony	Folds
1. From San Diego jetty, outer harbor.	22-20-23-20-22-22-20-19-22-23-23-19 20-21-19-21-22-23-20-22.
2. From San Diego piles, inner harbor.	21-19-20-21-19-19-20-21-20-21-20-21 16-21-22-21-23-22-22-21-16-20-16-19 20-21-22-18-22.
3. Santa Monica, 1st colony.	20-19-18-20-21-19-19-19-21-20-19-20 22-19-18-19-21-22-20-19.
4. Santa Monica, 2d colony.	14-12-12-12-12-14-12-12-14-13-14-12 14-14-15-14-13-14-14-13.
5. Pillar Point.	16-15-15-15-14-14-14-15-15-15-14 15-15-16-14-14-14-14-15-14.

The data contained in the above table are presented as a little study on the problem of variation of organisms produced monogenetically. The two facts revealed by them are sufficiently significant to warrant their publication, indicating as they do the desirability of subjecting the point to a special investigation. First there is a considerable range of variation among the zooids in a colony, the extremes being 16 and 23 in colony number 2. This result is not in harmony with the widely held notion that variation does not take place to any extent among individuals produced asexually from the same parent. The second notable fact is that some of the colonies, especially number 4, have a very distinct mode of their own. The question as to whether we have here a case of what may be called somatic heredity obtrudes itself and invites experimental study.

#### **Amaroucium solidum, n. sp.**

Pl. 46, figs. 69 and 70

*Superficial characteristics of the colony.*—Large, fleshy, potato-shaped lobes; young colonies more globular; largest colony studied, length 16 cm., width 7 cm., thickness 3.5 cm. Some living colonies opalescent white, the zooids showing as opaque white objects; others opalescent with a yellowish blue tinge, the zooids distinctly yellow. Zooids very numerous, standing at various angles in colony. Systems seemingly never present. Test gelatinous with many variously shaped pigment grains; surface layer tougher than underlying portion.

*Zooids.*—A little pressure on a living colony forces zooids out upon surface; easily removed from test in preserved specimens; varying greatly in length, some very long, extending well back into central gelatinous core; average length in large colony, thorax 3 mm., abdomen 2 mm., postabdomen 8 mm. Mantle delicate and transparent, containing about twenty-four longitudinal muscle bands on a side, these separated by considerable spaces in the thorax but closer together in the abdomen and postabdomen; a few transverse fibers in the siphonal region.

*Branchial system.*—Branchial siphon with six blunt lobes grooved so as to appear twelve when viewed from above; atrial siphon with short, overhanging, triangular languet and five small, pointed lobes. Branchial sac with from thirteen to fifteen series of stigmata, each series having about fifteen stigmata on a side in middle of sac (pl. 46, fig. 69). Endostyle wide and straight, with a narrow space on each side free from stigmata. Branchial tentacles about twenty, of varying sizes.

*Digestive system.*—Plane of intestinal loop, transverse; esophagus almost as long as stomach; stomach cylindrical, one and one-half times longer than wide, having about eight folds, these sometimes discontinuous (s., fig. 69); intestine divided into several parts (pl. 46, fig. 70); first, a piece a little shorter than stomach with a bulge about mid-



way of its length; second, a larger section which makes the loop; third, a short, very narrow isthmus connecting the large piece just described with rectal limb, the beginning of which is provided with prominent caeca; and finally, the rectal piece running up left side of body to end as a constricted anus about one-third the distance up branchial sac.

*Postabdomen and reproductive system.*—The postabdomen variable in length, often three or four times as long as thorax; about half the diameter of thorax, tapering toward posterior end. The conspicuous cloison, or partition, halves the cavity of postabdomen from right to left; many round pigment granules occurring in walls of this partition. Numerous regular testis lobes occupy posterior half of postabdomen. The ovary (*o.*, pl. 46, fig. 69) just anterior to the latter, quite remote from intestinal loop.

*Breeding season.*—Summer months at least, the atrial chambers of zooids examined at this time being filled with tadpoles.

*Habitat and distribution.*—The only localities from which specimens have been certainly identified as belonging to *A. solidum* are San Diego Bay and Santa Monica, where they were taken from piles in both localities. Almost certainly, however, the species occurs in Monterey Bay and other northerly points.

*Type locality.*—San Diego Bay.

The great variability in the colonies of *A. californicum* makes the species seem to include *solidum* so far as external appearance is concerned, and since the two overlap a good deal in distribution, if indeed they are not coincident, the collector is likely to confuse them at times. In general, however, the much greater massiveness of *solidum* will distinguish them even to cursory observation. But examination of the zooids leaves no question about the specific distinctness of the two. Perhaps the most accessible point of distinction between the zooids of the two is in the secondary lobing of the lobes of the branchial siphon of *A. solidum* and the teeth around the atrial orifice in the same species.

*A. solidum* has much in common with *A. obesum* Sluit. (Sluiter, 1900) from the Chatham Islands. But the two are well distinguished, seemingly, by a number of characteristics, notably the undivided branchial lobes and the absence of denticles around the atrial orifice in *obesum*. In fact, the two positive characteristics in *solidum* are very exceptional in the genus *Amaroucium*.

### ***Amaroucium aequali-siphonis*, n. sp.**

Pl. 38, fig. 4; pl. 45, fig. 61

*Superficial characteristics of the colony.*—Consisting of long, pedunculated, club-shaped lobes, completely encrusted with sand, each growing from a basal network. Both head and peduncle of each lobe

usually flattened throughout its entire length; heads not sharply set off, but tapering gradually into peduncle which becomes gradually smaller until attached end is reached. New lobes spring at times from substratum and result in a dense growth of more or less parallel, slender lobes (pl. 38, fig. 4). Sometimes many lobes arise from a common center, resulting in a more or less spherical body whose surface is made by the heads of the lobes. In this form of growth the heads of the lobes have a broader anterior expanse than in the form first described; the lobes themselves sometimes branched. Test gelatinous and transparent, but having a dirty tinge due to innumerable small test cells. No common cloacal orifices present. Length of longest lobes about 2 cm., width of heads about 7 mm., thickness 3 mm.

*Zooids* (pl. 45, fig. 61).—Not arranged in systems; both siphons opening on surface of distal ends of lobes of colony; long and slender, the postabdomen extending through almost entire length of peduncle to end in a slight swelling which contains heart; abdomen somewhat longer than thorax. Mantle contains longitudinal muscle bands which run length of zooid and are separated by considerable spaces over thorax and abdomen, but are closer together in postabdomen.

*Branchial system*.—Both orifices distinctly 6-lobed. Branchial tentacles about twenty, alternating long and short. Branchial sac with eight series of stigmata, about fifteen stigmata in a half-series. Dorsal languets about as long as stigmata (pl. 45, fig. 61).

*Digestive system*.—Intestinal loop somewhat longer than branchial sac, its plane oblique to sagittal plane of zooid; esophagus about equal in length to stomach, tapering to a small diameter at its entrance into stomach; stomach somewhat longer than broad, wall longitudinally folded, the folds, never more than six or seven, sometimes broken, often one whole side practically foldless; portion of intestine between stomach and loop about twice as long as stomach, constricted about midway in its course; a small, short tube intercalated into intestine at beginning of rectal limb; lobed anus located a little anterior to middle of branchial sac (*a.*, pl. 45, fig. 61).

*Reproductive system*.—Ovary posterior to intestinal loop, not in contact with it; testis lobes numerous, beginning just posterior to ovary and extending through entire postabdomen (*o. t.*, pl. 45, fig. 61).

*Habitat and distribution*.—So far the species has been taken only at Rincon Point, Santa Barbara, California. It belongs to the littoral zone alone, so far as we know.

In spite of the violence done to the genus *Amaroucium* by forcing this species into it, after much deliberation we have decided that for the present, at least, to do so is justifiable. As will be seen from the description and figures, the animal is a perfectly typical member of the genus in every respect except possibly the character of the colony and certainly the form of the atrial orifices of the zooids. The pedunculation and lobulation, and the sand-encrustation of the colony, though not altogether typical are by no means unique, the type species

*proliferum* M. Edw. of *Amaroucium* being, as is well known, pedunculated. And numerous species are more or less sand covered.

The serious difficulty is in the entire absence of an atrial languet and the regular 6-lobing of the orifice. But although the possession of a languet is rightly regarded by most authors as one of the best generic characters of *Amaroucium*, a comprehensive review of the genus reveals the fact that while in the great majority of the species the languet is distinct and large, a fairly complete series from the langueted orifice to the regularly lobed type like that in our animal, exists.

*A. complanatum*, Herdm., and *A. pallidum*, Herdm. are described by their author (Herdman, 1891) as having the atrial languet short and inconspicuous. In *A. pribilofense* Ritt. (Ritter, 1899), the languet is "very variable in length, in some zooids the siphon departing but slightly from the normal 6-lobed condition." And finally in *A. anomalum* Herdm., the atrial siphon is wholly absent, judging from the author's figure; the point is not mentioned in the text (Herdman, 1899, pl. Pl. III, fig. 14).

Nor could one expect otherwise than that a range of variety like this would occur in a genus of many species when he considers the abundant evidence that the atrial languet is, phylogenetically speaking, a late differentiation from the normal, evenly bordered siphon. On the whole, therefore, we have thought it more warrantable to place the species in this genus than to adopt the next best alternative—that of establishing a new genus—a course which may be necessary at some future time when a study shall have been made of the kindred animals from the whole California coast. We have observed several other closely similar ascidians from points north of Point Conception, and an exhaustive study of all these may necessitate a change in the present disposition of the species now under consideration.

In concluding, for the present, these remarks on the taxonomy of this species, we would point out that were the genus *Sigillina* to stand substantially as described by Savigny, these California species would probably accommodate themselves more easily to it than to any other of the numerous small off-side genera of the family Synoicidae (Polyclinidae). If, however, *Sagillina* really belongs to the Polycitoridae (Distomidae) as is now held to be the case, there would be no possibility of placing our species in this genus, for its polyclinid characteristics are unequivocal.

***Euherdmania claviformis* (Ritt.)**

*Herdmania claviformis*, Ritter, 1903, p. 237.

*Euherdmania claviformis*, Ritter, 1904, p. 650.

*Euherdmania claviformis*, Hartmeyer, 1909, p. 1470.

This is one of the abundant ascidians on the southern as well as on the central and northern California coast. In the vicinity of La Jolla, for example, it is found in great abundance on the under side of rocks at low tide. Apparently it is confined to the littoral zone.

On the whole the zooids are somewhat smaller in southern than in northern colonies.

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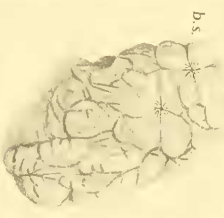
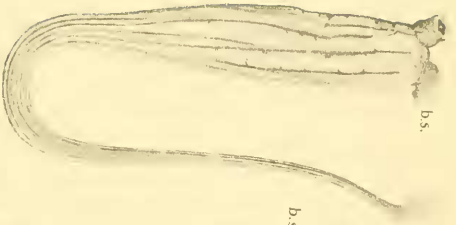


## EXPLANATION OF PLATES

### PLATE 38

- Fig. 1. *Styela montereyensis*. Whole animal. Natural size.
- Fig. 2. *Styela barnkarti*. Whole animal, a little larger than natural size.
- Fig. 3. Colonies of *Macroclinum par-fustis*, joined by basal stolons of test. Natural size.
- Fig. 4. Colonies of *Amaroucium aequali-siphonis* joined by basal stolons of test. About twice natural size.
- Fig. 5. *Molgula verrucifera*. Three animals.  $\times 2$ .
- Fig. 6. *Ascidia californica*. Whole animal. Natural size.
- Fig. 7. *Polyzoa translucida*. Zooids joined by basal stolonie network and growing among the branches of a young hydroid. Natural size.
- Fig. 8. *Metandrocarpa michaelsoni*. Zooids connected by trails of test. Natural size.



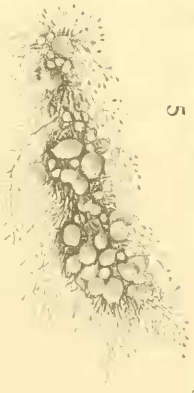
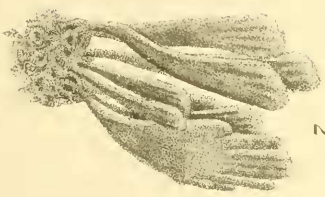


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PLATE 39

Fig. 9. Colony of *Macroclinum pellucidum* with zooids seen through transparent test.  $\times 6$ .

Fig. 10. Small portion of a colony of *Botryllus tuberatus* showing a single system of zooids, two tuberlike masses of ectodermal ampullae, *c.a.*, and ectodermal vessels.  $\times 8$ .

Fig. 11. Colony of *Didemnum carnulentum*.  $\times 2$ .

Fig. 12. A single system of *Botryllus tuberatus*, showing character of the common cloacal orifice. The lower lip of atrial siphon extends beyond edge of common orifice.  $\times 8$ .

Fig. 13. Colony of *Glossophorum planum*. Natural size.

Fig. 14. Three zooids of *Metandrocarpa michaelsoni* showing trails of test and ectodermal processes.

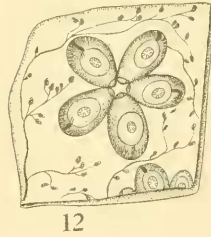
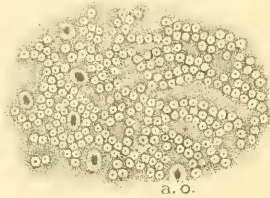
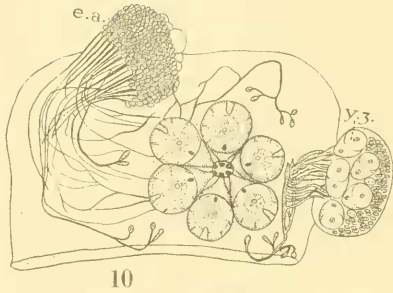
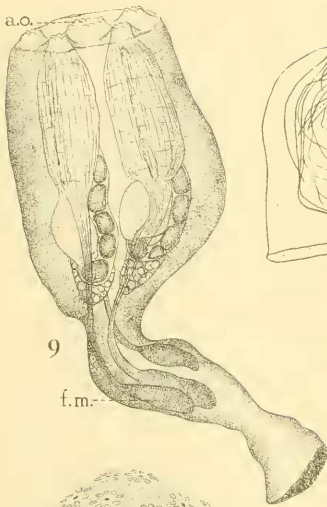




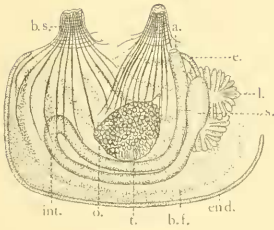


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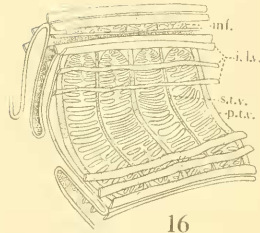
Fig. 15-20, *Molgula verrucifera*.

- Fig. 15. Animal viewed from left side, test removed.  $\times 4\frac{1}{2}$ .  
Fig. 16. Portion of branchial sac showing three folds.  
Fig. 17. Tip of atrial siphon showing processes.  
Fig. 18. Tip of branchial siphon showing processes.  
Fig. 19. Branchial tentacles.  
Fig. 20. Hypophysis and ganglion.  
Fig. 21 *Diplosoma caulleryi*. Zooid viewed from right side.  
Fig. 22. *Botryllus tubercatus*. Zooid enlarged, view from left side especially to show the snout-like atrial siphon, *a.s.*  
Fig. 23. *Didemnum carnulentum*, var. *lacteolum*. Zooid much enlarged, viewed from left side.





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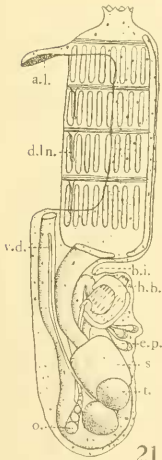
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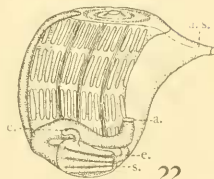
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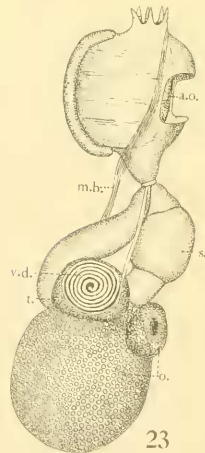
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PLATE 41

Figs. 24-27, *Ascidia californica*.

Fig. 24. Animal viewed from left side, test removed. Natural size.

Fig. 25. A portion of tentacular circlet and hypophyseal region seen from within.

Fig. 26. Stomach and intestine viewed from right side to show ramifications of ovary and testis.

Fig. 27. Two lobes of atrial siphon showing the bordering teeth and pigment spots.

Figs. 28-34, *Styela montereyensis*.

Fig. 28. Animal, with test removed, viewed from the right side, showing position of the reproductive organs. Natural size.

Fig. 29. Same viewed from left side.

Fig. 30. A portion of the tentacular circlet and hypophyseal region seen from within.

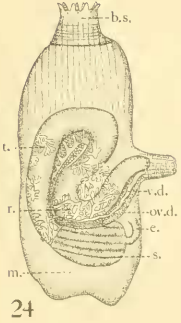
Fig. 31. Anterior portion of ovary, viewed from the inner surface.

Fig. 32. Atrial siphon cut so as to expose part of velum with atrial branches.

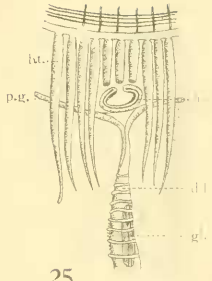
Fig. 33. Spinule

Fig. 34. Spinule.

Fig. 35. *Styela yakutatensis*. Spinule.



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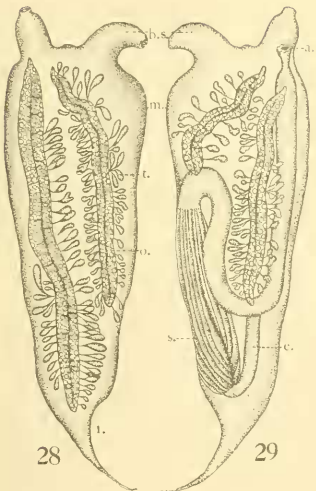
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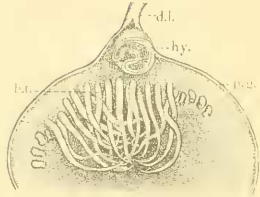


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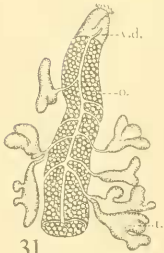


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PLATE 42

Figs. 36-38, *Polyzoa translucida*. Animal much enlarged

Fig. 36. Viewed from left side with test removed.

Fig. 37. Same viewed from right side.

Fig. 38. Hermaphroditic gonads.

Figs. 39 and 40, *Styela barnharti*.

Fig. 39. Animal with test removed, viewed from the right side and with muscle bands of mantle indicated only in siphonal regions. Natural size.

Fig. 40. Same viewed from left side, with muscle bands of mantle indicated only in siphonal regions. Natural size.

Figs. 41-45, *Metandrocarpa michaelsoni*.

Fig. 41. Animal much enlarged, viewed from left (lower) side, test removed.

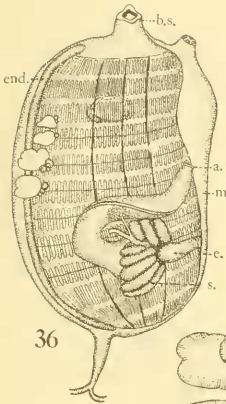
Fig. 42. Same viewed from right (upper) side.

Fig. 43. Branchial tentacles, hypophysis, ganglion and gland viewed from inside.

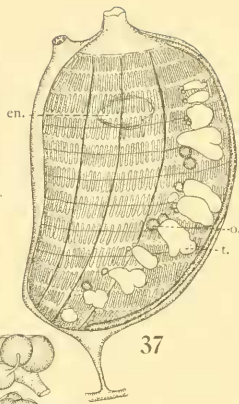
Fig. 44. Atrial tentacles.

Fig. 45. Testis masses attached to mantle.

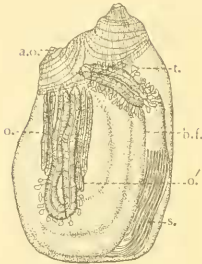




36



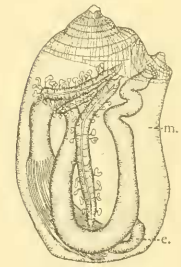
37



39



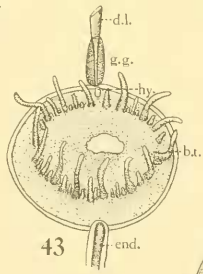
38



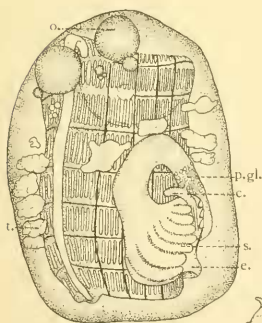
40



44



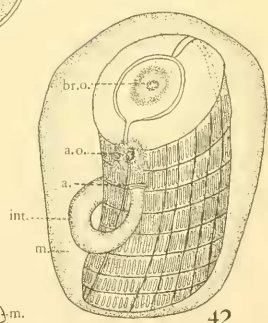
43



41



45



42

